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SCIENCE AND ITS SOCIAL RELATIONS

THE resolutions adopted by the Committee on Science and its Social Relations of the International Council of Scientific Unions at its meeting in Paris during June 15–16, and which have been forwarded to the scientific press and to scientific institutions, reflect faithfully the trend of thought among a considerable body of scientific men throughout the world. The recent review of the work of the Rockefeller Foundation in 1947 by its president, Dr. Raymond B. Fosdick, gives witness to similar views. At this meeting, Dr. C. H. Desch was the only British representative, Prof. F. J. M. Stratton, who was chairman during 1937–48, having retired on appointment as deputy scientific adviser to the War Office. The resolutions were the outcome of extensive discussions on the method of working to be adopted by the Committee and on its future programme of work, and in this connexion the first resolution affirms the opinion of the Committee that the most urgent problems of the social relations of science are to-day, first, the dangers threatening science from the fact that research in large measure has become dependent on military sources and on industry for its financing, and secondly, the way in which the results of science are actually introduced into society.

Both these problems were emphasized by the Committee in the circular letter issued in October 1947, and the first is the subject of keen debate in the United States at the present time. While the extension of Government research is regarded with a measure of distrust, a couple of recent articles indicate like concern at the growing practice of using university laboratories for the conduct of research sponsored by industry, and urge that the support which industry gives to university research should not be tied to the financing of particular projects, beyond designating a broad general field of research. Mr. S. Tout condemns outright the arrangements announced in the *New York Times* last January between seven industrial firms and the University of Chicago in regard to atomic research as not in the public interest. He urges that universities and like institutions should discontinue research for private enterprise and limit themselves to research for the public benefit.

The position in this matter varies from one country to another, and there does not appear to be any reason for believing that in Great Britain there is at present any serious danger that the direction of academic research is being deflected by industrial endowment. Endowments, such as the research fellowships established by Imperial Chemical Industries, Ltd., or Turner and Newall, Ltd., are entirely free from such restrictions other than that the research is to be conducted in some specific branch of science. Any malaise in Britain is rather related to the dangers arising from the subvention of research from military sources to which the Committee on Science and its Social Relations directs attention in its third resolution. The Committee believes that the increasing influence of the military on scientific research will lead sooner or later through its secrecy

restrictions to the abrogation of the traditional freedom of expression and of publication, and will result in directed research not planned primarily for the benefit of science and mankind but rather for its destruction.

While it is possible that the fears entertained on this point are exaggerated, it seems just as certain that the Atomic Energy Commission must concern itself with the social implications of atomic power; for it is on that matter that liberty and equalitarian democracy become incompatible. Dr. M. H. Stone, of the University of Chicago, pointed out last year in *Science* (**105**, 507; 1947) that the Commission would have to concern itself with many questions which fall within the domain of the social sciences, and that it is important that similar attention should be given to the social effects of many other innovations flowing from our laboratories. Dr. Fosdick, in the Rockefeller Foundation report referred to above, clearly had the same point in mind when, in discussing the unity of science, he referred to the way in which the activities of the Institute for the Unity of Science in New York, towards which the Foundation made a grant in 1947, included research which cuts across the traditional demarcation lines of specialized disciplines and departments, the utilization of new knowledge in logic, the study of meaning and how it is communicated, and research on the philosophical, psychological and sociological backgrounds of science.

More important, however, in this connexion is the stress which Dr. Fosdick lays elsewhere in his report on the dependence of the health of the intellectual life of the world upon the free and unhampered exchange of ideas and personnel between universities and research institutions in all countries. Achievement is usually the result of the sustained thinking of many minds driving toward a common goal in many countries. The creative spirit of man, Dr. Fosdick once more reminds us, cannot be localized or nationalized. Ideas are starved when they are fenced in behind frontiers, and barricaded research in the long run leads to intellectual stagnation.

This is why Dr. Fosdick considers that the heavy concentration in the United States of research in atomic physics is unfortunate. However necessary for the time being from the security point of view, from the point of view of the growth of knowledge the arrangement is unhealthy. All knowledge is so interlocked that we cannot control research on the destructive aspects of atomic energy without at the same time interfering with world-wide research on its beneficent possibilities. Those American men of science who suggested the postponement indefinitely of the industrial development of atomic power not only recognized the impracticability of separating the development of nuclear power for industry from the growth of atomic-bomb power, but also that in the harnessing of forces which might bring incalculable benefit to mankind, knowledge could be retarded through lack of the cross-fertilization brought about by the exchange of knowledge.

Dr. Fosdick observes further in this connexion that in the history of modern science no single country by itself has ever had the intellectual resources or the imagination to bring to full fruition all the potentialities of a new idea, and he comments on the unfortunate growing isolation of the scientific workers and scholars of Eastern Europe. The high level of creative research of the distinguished mathematicians of the Soviet Union, her imaginative work in biomedicine cannot be maintained if the Soviet Government prevents direct and intimate relations with workers in these same fields in other parts of the world. Isolationism is a blight which saps the vitality of everything it seeks to preserve.

Set in this context, the statement issued in Great Britain in July by the Atomic Scientists' Association seems lamentably weak and compares poorly with the report "Policy at the Crossroads" in which the U.S. State Department has recently summarized the efforts of the United States and other Governments during the last two years to secure the adoption of an effective system for the control of atomic energy. Undoubtedly it is clearer than it was in 1946 that the sources of disagreement between the major Powers are so deep that the institution and working of a control scheme are much more difficult than at first supposed, and that there is little chance of agreement at the moment on the lines of the Lilienthal proposals or on any more limited scheme. The United States Government is naturally enough unwilling to abandon its lead in atomic weapons without a complete system of inspection and control which would ensure that no other country was building up such armaments to use against America. On the other hand, the Soviet Union believes that in any control authority acceptable to the United States, the countries voting with the U.S.S.R. would be in a minority and that the development of atomic energy in the U.S.S.R. would pass under foreign direction. The attitude of Soviet Russia may also be determined by the view that any complete scheme of inspection would give the outside world information of strategic value about the location of their industry.

While, therefore, a substantial change in international relations is necessary before any such plans can be revived with any hope of success, the Council of the Atomic Scientists' Association quite rightly records its continuing belief that some form of international control is the most desirable ultimate solution of the problem of atomic weapons. The Council believes that the solution can now be sought only through the constant promotion of all measures designed to make war less likely, and to reach a settlement between East and West. In its anxiety to avoid taking sides, however, the Council of the Association has become vague. The commendable attempt to avoid political bias is carried too far when it avoids passing judgment on the facts. It is scarcely an act of partisanship to point out that the man of science in the modern totalitarian State is essentially a servant of the State, and that it is treason, as indeed the law promulgated last year in the U.S.S.R. illustrates, for him to divulge any knowledge whatever, save as the State allows. The Association does less than justice to the respect of British and American scientific workers for the full tradition of scientific freedom, or to their freely expressed impatience at

every restriction imposed on them in the name of security. No instinctive inhibitions will hamper British or American scientific workers in the exchange of scientific information; but it is at least arguable that collaboration as suggested by the Atomic Scientists' Association is more likely to promote, for the present, a one-way traffic to the disadvantage of the Western democracies. That is undoubtedly the real reason why the American–Soviet Science Society has had to cease its efforts to promote the interchange of scientific ideas between American and Soviet scientific workers. If an improvement in political relations is a first condition of cultural intercourse, the Atomic Scientists' Association may well have rejected a shade too cursorily the proposal for a moratorium in the development of atomic energy, or that a control scheme should be established of those nations which were willing to submit to the essential inspection and other measures.

No one would pretend that such a partial control scheme would eliminate the need for secrecy, though it might limit the area, and it could not well intensify the suspicion which already exists between East and West. What it could do is demonstrate the practicability of inter-nation control over an area in which political conditions and relations gave the control a chance to operate, and in this way it might permit international control in the full sense to be achieved at an earlier date once the political situation in the world as a whole had become favourable. The Committee on Science and its Social Relations does not touch on this specific problem; but in more general terms points out that the actual problems involved in all social relations of science are problems concerning men's attitude to scientific knowledge and to its application, in particular, to the power given by science.

For this reason the Committee proposes to address itself to a number of scientists, sociologists, persons prominent in educational work, and others to ascertain their opinions on the measure in which the methods of international scientific work contribute to the creation of an international spirit and to the maintenance of peace and on the ways in which scientific organisations and scientific men could intensify their activities for the maintenance of peace. This inquiry should be terminated before the end of September 1948, and the results will be presented to the secretariats of the United Nations Organisation and of its Educational, Scientific and Cultural Organisation as well as to the International Scientific Unions. It appears from the memorandum that the Committee contemplates investigations into these problems with the help of psychology, the social sciences, economics and juridical science as well as of the medical, agricultural and engineering sciences. In particular, the Committee urges the United Nations Educational, Scientific and Cultural Organisation to promote the formation of international organisations representing the medical and the engineering sciences. It is true that the composition of the Committee on Science and its Social Relations gives it little authority to speak for the engineering and medical sciences: even for the physical sciences its basis may well be regarded as altogether too narrow to be representative. If that limitation is kept in mind, the proceedings at its meeting last June demonstrate that the Committee should nevertheless prove of real value in indicating gaps in the field which need attention, and in stimulating thought about general and particular problems.

In both respects it can be claimed that the present memorandum merits careful consideration by the world of science, and as Dr. Lampitt recently remarked in Edinburgh, at the annual meeting of the Society of Chemical Industry, too little is known, in Great Britain even, of the work of the international unions. Besides its observations on the danger to science inherent in subvention from military science, the Committee elaborated the principles of a Charter for Scientists which deserve full discussion, and in particular from the point of view of their practicability in industrial as well as in Government employment. It also focuses attention on two other prineipal aspects of the social relations of science: the changes introduced in human societies through technological developments of science; and the antagonisms between biological order and social order.

In regard to the first of these, the Committee suggests for investigation as soon as possible, in addition to subjects already proposed by the secretariats of the Natural Sciences Section of the United Nations Educational, Scientific and Cultural Organisation, the effect on society of such developments as vitamins, new races of wheat and other food grains, artificial insemination, television, products derived from nylon, antibiotics, sulphonamides, etc., and the medical applications of artificial radioactive elements. As a first step, it is proposed to create two subcommittees to consider the formation of study groups to investigate the various items, and another subcommittee will be formed to organise meetings of specialists where the points of view of the biologist, the sociologist and the psychologist can be brought to bear on the explanation of antagonisms between human biology and society.

The Committee on Science and its Social Relations may thus be making a much more vital contribution to the development of international understanding than the Atomic Scientists Association or like bodies are able to do at the present time. It is, of course, important that there should be no duplication of effort, and that the limitations of what is practicable at the present time should be kept in mind. Fortunately, the memorandum from the Committee on Science and its Social Relations indicates that the Committee is anxious to work harmoniously with the International Council of Scientific Unions and the United Nations Educational, Scientific and Cultural Organisation, and that it only proposes independent action where gaps are clearly seen to exist, and then by agreement as to the means to be used. There can, therefore, only be welcome for this further declaration as to the dependence of scientific advance on full freedom of communication and discussion, and for the proposals to foster fresh opportunities for contact between creative minds at those borderlands of the sciences which have in the past proved so often their fertilizing and stimulating power in intellectual effort.

LAWS AND CONSTITUTIONS

The Federalist, or the New Constitution

By Alexander Hamilton, James Madison and John Jay. Pp. lxxi + 484. (Oxford: Basil Blackwell, 1948.) 9*s*. 6*d*. net.

A Fragment on Government and An Introduction to the Principles of Morals and Legislation

By Jeremy Bentham. Pp. lxvii + 435. (Oxford: Basil Blackwell, 1948.) 9*s*. 6*d*. net.

IN an interesting comment on "The Federalist", immediately after the publication in 1788 of the last of the essays of which it is composed, Washington wrote to Hamilton: "When the transient circumstances and fugitive performances which attended this crisis shall have disappeared, that work will merit the notice of posterity, because in it are candidly discussed the principles of freedom and the topics of government, which will always be interesting to mankind, so long as they shall be connected in civil society". With the rapid increase of American power in the past half-century, and the significant emphasis placed upon the 'American way of life' in current political agitations, it is important that some effort should be made to understand the influences that have shaped the growth of the great Republic, and "The Federalist" must always stand as a revealing commentary on the struggles of its early days. Here it is presented in the simple but attractive format of Blackwell's "Political Texts" series, with a valuable introduction by Max Beloff.

The work is essentially a practical contribution to the controversies that raged about the constitution of the new United States during 1787–88; but at the same time, as Washington's comment suggests, it is concerned with some of the fundamental problems of politics. While seeking to justify the constitution, it also provided, by inference, a cautious analysis of society and of society's instrument, the State. But the analysis of society is based upon a belief in natural rights that was characteristic of the age and that had already found expression in the challenging words of the Declaration of Independence. Government and law, it was held, had the limited task of preserving natural rights, and especially the rights of property: "As long as the reason of man continues fallible . . . different opinions will be formed. . . . The diversity in the faculties of men, from which the rights of property originate, is not less an insuperable obstacle to an uniformity of interests. The protection of those faculties is the first object of government. From the protection of different and unequal faculties of acquiring property, the possession of different degrees and kinds of property immediately results; and from the influence of these on the sentiments and views of the respective proprietors, ensues a division of the society into different interests and parties. . . . A landed interest, a manufacturing interest, a mercantile interest, a moneyed interest . . . grow up of necessity in civilized nations. . . . The regulation of these various and interfering interests forms the principal task of modern legislation."

It would be unwise to read into this more than it was meant to convey; but here, as elsewhere in "The Federalist", are to be found the origins of the differences over the interpretation of 'democracy' that to-day divide east and west. Many of the ideas of the work look back to Locke a century earlier; but the framers of the American constitution were able to go far beyond Locke in basing their new system on a fundamental, written constitution. To this fact is to be attributed much of the static quality and legalistic character of the constitutional development of the United States, modified though this has been, from Jefferson to Roosevelt, by new glosses. In short, "The Federalist" is a valuable contribution to the study of contemporary history. The philosopher may condemn its limitations; but it has been described as "the finest study in the economic interpretation of politics which exists in any language", and, as Mr. Beloff rightly points out, "a text which can still be argued about, is a text worth reading". It has, moreover, acquired a new significance through the present discussions on "Western Union".

The American Declaration of Independence was issued in 1776, a year which proved to be something of an *annus mirabilis*, for it saw also the appearance of two other works of lasting influence, namely, Adam Smith's "Wealth of Nations" and Bentham's "Fragment on Government", which was itself a commentary on yet another book of importance in the political evolution of Britain and America, Blackstone's "Commentaries on the Laws of England" (1765). In the same year, too, Bentham was working on an introduction to a new penal code, which finally appeared in 1789 as "An Introduction to the Principles of Morals and Legislation". The "Fragment" and "Principles", Bentham's earliest works, now appear together in a convenient volume, introduced in a clear and balanced survey by Mr. Wilfrid Harrison. The two works, Mr. Harrison claims, "occupy a special place in political theory. They are the first major works in which a clear statement is given of the nature of government as an instrument the value of which is to be judged by its effects, and in which at the same time far-reaching claims are made in regard to the potential effectiveness of government." Earlier philosophers who had written of the State as a human rather than a divine institution had concerned themselves far more with the contractual obligations underlying it than with its actual working. Bentham, like the authors of "The Federalist", turned to practical issues, and sought by a critical examination of the conduct of man in society to suggest the lines of improvement. His own copy of the "Fragment", as Mr. Harrison reminds us, was inscribed by him: "This was the very first publication by which men at large were invited to break loose from the trammels of authority and ancestor-worship on the field of law"; while the very opening of the work links investigation ("discovery") with "reformation".

Bentham was thus typical of the best that his age could produce, though his influence was not widely felt until the great period of reform that opened in the eighteen-twenties, towards the end of his long life. Whether, but for the French Revolution and the horror of change that it excited, he could have achieved more at an earlier period cannot now be decided; but the influence of this typically eighteenth-century thinker of the pre-industrial era is writ large upon the history of Britain and British ideas in the nineteenth century. That influence flowed largely from Bentham, the philosophical radical of the later period. The interest of these earlier works lies partly in the optimistic view of human nature which led him later to declare of the period in which they were written that he "never suspected that the people in power were against reform; [he] supposed they only wanted to know what was good in order to embrace it". Utilitarianism is now a largely discredited creed; but its place in nineteenth century developments

cannot be ignored. Bentham's work, vast in quantity, was fragmentary and limited in scope; but his method of critical thinking, as set out, for example, in the closing words of the "Fragment", was sound, and with "The Federalist" in mind one may read with interest its application in the "Principles" to the ideas of the Declaration of Independence. "With men, who are unanimous and hearty about *measures*", Bentham wrote, "nothing is so weak but may pass in the character of a *reason*." The remark, and the method, have lost none of their validity during the period of nearly two centuries since these words were set down.

MAURICE BRUCE

BERKELEY: FATHER OF PLANT PATHOLOGY

Phytopathological Classics, No. 8

Observations, Botanical and Physiological, on the Potato Murrain. By M. J. Berkeley; together with Selections from Berkeley's "Vegetable Pathology" made by the Plant Pathology Committee of the British Mycological Society. Pp. 108. (East Lansing, Mich.: American Phytopathological Society, 1948.) 1.50 dollars.

MODERN farmers and gardeners are now well acquainted with the possibilities of control of plant disease. Should a new trouble be found, it is usually only a matter of time before a palliative or remedy is discovered. It is, therefore, somewhat difficult for us to realize the state of passive acceptance of crop 'blights' which prevailed a century ago. We can, however, give a far greater measure of appreciation than could be accorded by his contemporaries to the Rev. Miles Joseph Berkeley. He, more than any other, established on a sure foundation the conception of plant disease caused by parasitic fungi.

It is true that fungi had been found growing on plants to their detriment before Berkeley's classic paper on the 'potato murrain' appeared. There was, however, no clear indication whether they were the primary cause, or a secondary effect, of the diseased condition. Berkeley's full powers were called forth by his celebrated literary controversy with Dr. John Lindley, who stated the purely physiological view that the 'murrain' was due to disturbed water relations resulting from unusual climatic conditions. It is impossible not to feel reverence for the scholarship and erudition of Berkeley's paper. Now that it is reprinted in this classic form, it can provide background for teacher and student, and still give inspiration to the more specialized mycologist.

The selections from "Vegetable Pathology" made by the Plant Pathology Committee of the British Mycological Society provoke rather a different note of humility. The completeness of Berkeley's conception of disease as abnormal functioning of plants finds, as yet, no corresponding completeness in modern studies. We are, alas, only too well acquainted with 'Congelatio, freezing' and 'Sphrigosis, rankness', but know all too little about them. Should anyone ask us the cause of 'Exostosis, hard excrescences consisting of sound tissue', we can only say we know they occur, and shake our heads about the cause. It is not that we have been idle, for studies on virus, on mineral deficiencies and on some non-parasitic maladies have explained many of Berkeley's classified diseases. The science of genetics has elucidated still more. The real shortcoming is that whereas Berkeley directed the attention of mankind to damage caused by parasitic fungi, and showed that it was amenable to control—he it was who suggested the use of sulphur and lime to Mr. Tucker—the science of plant pathology languished until twenty years ago. It then began to gather momentum, is now beginning to command the respect of practical growers, and should look forward to a brighter future.

JOHN GRAINGER

FROM RADIUM TO THE ATOMIC BOMB

Atomic Energy

By Dr. R. R. Nimmo. (Frontiers of Science Series.) Pp. 201. (London: Pilot Press, Ltd., 1947.) 9*s*. 6*d*.

THE 'Frontiers of Science' series, of which this is the first number, is stated to be "intended for the growing non-specialist public which wants to keep abreast of recent scientific developments and so keep pace with a changing world". Atomic energy is undoubtedly one such important scientific development, and the general editor of the series, Dr. A. C. B. Lovell, has chosen well in asking Dr. Nimmo to write an account of the progress made in nuclear physics from the discovery of radioactivity in 1896 to the release of the first atomic bomb in 1945. Dr. Nimmo was, during the Second World War, a member of the British team engaged on the atomic bomb project in the United States, and has since been working at the University of Birmingham on the construction of particle accelerators, so that he writes on his subject with considerable authority and knowledge. It is true that Dr. Nimmo divulges no secrets, nor gives any information that is not contained in the official Smyth Report; but he does not hesitate to read between the lines and to set down in detail all reasonable deductions that an expert in this field can make from the official information.

To those with a moderate knowledge of chemistry and physics the first half of the book can be recommended as an excellent introduction to modern atomic structure and as an account of modern experimental techniques. The second half of the book deals with nuclear fission, chain reactions, uranium piles, plutonium, the atomic bomb and atomic energy plants, and will be read with interest by all who have not access to, nor the time nor ability to wade through, the mass of uncorrelated information which has been published during the last few years.

The last chapter of the book, on atomic energy and the future, is naturally speculative, but the problems to be faced and overcome are clearly stated, and the difficulties in the way of rapid development of nuclear physics, such as considerations of military security and the delay in the declassification of fundamental data, are specifically mentioned. The author's attitude is well summed-up in the concluding sentence of the book, "The future is full of hope and promise, but only if we see to it that never again are these new powers used for killing and destruction".

The reviewer has two faults to find with this otherwise excellent book. One is that, though reference is made to the health hazards in atomic energy work, little or no reference is made to the great benefits of the use of radioactive tracers in medicine, agriculture and industry. The other is the unusual arrangement of type and size of page, which, with its long close lines, is very fatiguing to the reader.

S. WEINTROUB

UNIVERSITY EDUCATION IN NOTTINGHAM

By Prof. H. T. H. PIAGGIO

ON July 9, 1948, the King in Council conferred full university status upon University College, Nottingham, so that the efforts of more than seventy years were crowned with success. In 1875 Mr. Richard Enfield asked the Nottingham Corporation to erect buildings to accommodate the Cambridge University extension lectures then being delivered in the city, and to add a library and a chemical laboratory. An anonymous donor offered £10,000 for this purpose. The Corporation adopted the scheme in an improved form, to include also a natural history museum and provision for the teaching of several branches of science, which up to then had been carried on by the Mechanics' Institute. The foundation stone was laid in 1877, and the College opened in 1881. At first there were only four professors, the Rev. J. F. Blake (natural sciences), Dr. F. Clowes (chemistry and metallurgy), Dr. J. A. Fleming (physics, mathematics and mechanics), and the Rev. J. E. Symes (English), with four lecturers, two demonstrators, and fifteen part-time teachers of science. Dr. Fleming (later Sir Ambrose Fleming, the inventor of the thermionic valve) left after one year, and was succeeded by Mr. William Garnett. At first there was no principal; but Dr. Clowes acted in this capacity from 1887 until 1890, and Mr. Symes from 1890 until 1911, both in addition to their professorial duties. A professor of engineering was appointed in 1884. In the following year the College started to train teachers. In 1893 a new wing was opened for the engineering and technical students, designed by the versatile Dr. Frank Granger, who later became professor of classics and philosophy. In 1898, Mr. Ernest Weekley, afterwards well known for his books on philology, became professor of French, and Dr. F. S. Kipping, from whose researches on the organic compounds of silicon the new silicone plastic industry has developed, became professor of chemistry. The culmination of this period of development was the Charter of Incorporation (as a University College) conferred by the Privy Council in 1903.

After this, for some reason, there was a check to the development. Perhaps the splendid initiative of the Nottingham Corporation in founding the College led the citizens to think that there was no need for them to take an active interest. Certainly the neighbouring counties considered it purely a Nottingham affair, which was no responsibility of theirs. In 1911 it became evident to Mr. W. H. Heaton, who after many years as professor of physics and mathematics had been appointed principal, that if a great effort was not made, the College was likely to decline. He established professorships of mining, economics and commerce, geology and geography, and history, and in 1913 there were hopes of a full charter. But in 1914 came war, and for four years the College was nearly empty. In 1919 the ex-Service men returned in embarrassing numbers, and the buildings were greatly overcrowded. The site in Shakespeare Street had very little room for expansion. There was difficulty in obtaining staff, and the financial position gave cause for anxiety. At a time when the difficulties seemed almost insuperable, Alderman E. Huntsman directed the attention of Sir Jesse Boot (afterwards Lord Trent) to the good work done by the College; thus, for example, an evening student, Mr. E. H. Barton, was able to become a professor of physics, a fellow of the Royal Society, and a recognized authority on acoustics. Sir Jesse's interest was aroused, and he allocated to the College a large site with a setting of exceptional beauty above the lake in University Park. Since then the College Council has acquired a good deal of adjacent land, and is now in the happy position of having room for as many lecture rooms, laboratories, and halls of residence as are likely to be required for very many years to come. The new buildings were opened by King George V in 1928; but for some years longer the Faculty of Applied Science remained in Shakespeare Street, Nottingham, which also remained the headquarters of the vigorous Adult Education Department set up in 1920 under Mr. (later Prof.) Robert Peers. This Department is one of the largest of its kind in Great Britain.

In 1930 Mr. Hugh Stewart became principal, and threw himself with great energy into preparing for full university status. In particular he emphasized the importance of research. He pointed out the necessity of transforming the governing body to take account of the fact that the College now served the whole of the East Midlands. Unfortunately, his incessant labours caused his untimely death in 1934. After a year with Dr. Granger as acting-principal, Mr. H. A. S. Wortley was appointed principal. He had gained an extensive knowledge of the needs of the area in his former capacity as professor of education, and his wide popularity enabled him to carry through changes which, though necessary, were sometimes a break with local traditions. In 1938 he obtained the supplementary charter, which reconstituted the governing body on the lines suggested by Principal Stewart. From 1939 until 1945 progress was again stopped by war. In 1945 the University College handed over the Shakespeare Street buildings and the responsibility for evening classes and technical education to a new authority, the Nottingham and District Technical College. In 1947 the Midland Agricultural College became part of the University College. In the same year was set up an Institute of Education, which will co-ordinate educational activities, including research, over a wide area.

It was anticipated that Principal Wortley's next achievement would be the attainment of a full charter; but worn out with the double burden of the war years, during which he also acted as deputy regional commissioner, his health collapsed, and he died suddenly in 1947. The arduous task of gathering up, at short notice, the many tangled threads of half-completed schemes was taken up by Prof. Peers, who, as acting-principal, had the satisfaction of reaching the goal towards which so many had striven for so long. He has also greatly strengthened the staff, made fuller provision for research, and drawn up the degree regulations for the new university. Mr. B. L. Hallward, for many years fellow of Peterhouse, Cambridge, and at present headmaster of Clifton College, will become the first vice-chancellor. The chancellor is Lord Trent, previously president and chairman of the College Council. He is the son of the College's great benefactor.

The University will start with five faculties, arts (including law, theology, music, economics and social administration), education, pure science (including pharmacy), applied science (mechanical, electrical and civil engineering, mining and fuels) and agriculture (including horticulture). New professorships

are being established, and new buildings erected. The number of students is now about three times that in 1938–39, and applicants have to be refused for lack of room. Negotiations to consider how the University and the technical colleges of the area can co-operate are in progress.

In addition to all the usual academic subjects (except medicine), the University will deal with certain special branches in which it feels particularly strong. It will continue the biochemical studies of the late Prof. J. M. Gulland, but with a shift of emphasis from nucleic acids to heterocyclic organic compounds of importance in chemotherapy. Pharmacy will continue to receive much attention, and will develop on the research side. Among other strong points are magnetism, mycology (with a graduate diploma), ecology and parasitology of freshwater fishes, soil mechanics, statistical methods, town planning, and Biblical and related studies. The East Midlands is an important mining area, and the University is dealing with the related geological problems, and with mine ventilation. Experiments in new methods of mine illumination are expected to contribute to the health and amenities of the workers at the coal face.

A Board of Local Studies has been set up. Contributions have already been made to Roman-British archæology, the history of the Civil War (which started in Nottingham) and of other national events with a local setting, also of economic conditions in the eighteenth and nineteenth century, particularly of the lace and hosiery trade. A valuable source of information about medieval social and economic conditions is now available in the University library, in which Lord Middleton and Mrs. Percy Clifton, representing two families which go back for many centuries, have deposited their family records. Economic conditions of our own time will be studied by the rapidly increasing Department of Economics and Social Study, which is now to be subdivided. We look forward with confidence to the contribution the University will make to the East Midlands, to the nation, and to the international fraternity of learning.

ENZYMATIC CONTROL OF CELL DIVISION IN MICRO-ORGANISMS*

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FROM lines of evidence converging from apparently widely separated fields it now appears possible to assemble evidence indicating that cell division in micro-organisms, and probably also in other organisms, is under the control of a unit enzymatic mechanism. The lines of investigation, developed quite independently, forming the foundations for this thesis are: (1) physico-chemical studies by Hinshelwood and co-workers[1] on the kinetics of bacterial growth and the state of balance between division and elongation; (2) the studies of Witkin[2] (genetic), Eisenstark and Clark[3] (electron microscope), and others[20,21,22] on irradiated bacteria; (3) cytochemical investigations of Pratt and Dufrenoy[4] on the mode of action of penicillin; (4) metabolic studies on dimorphic pathogenic fungi by Nickerson and Edwards[5]; and (5) examination of the chemical control of morphogenesis in yeasts by Jillson and Nickerson[6], the common denominator in all of these lines of investigation being a close examination of the effects of inimical or critical conditions on the morphogenesis of dividing cells. The examinations have revealed a common fundamental attribute of cell division of micro-organisms.

This fundamental attribute may be expressed by the use of a simple notation. Bacteria (B) may be induced to elongate into filaments (F) by various treatments which inhibit cell division but which do not simultaneously inhibit growth. The process itself may be denoted as a $B \rightarrow F$ conversion. Likewise with yeasts (Y), it is possible both to induce elongation into mycelia (M) structures through inhibition of cell division, and to inhibit the process in yeasts that normally show $Y \rightarrow M$ conversions as a characteristic feature. There are, furthermore, fungi which can be interconverted from a mycelial to a yeast form by changes in temperature alone, and for these it seems permissible to write $Y \rightleftharpoons M$ as an expression of the phenomenon. In the three cases the normal division mechanism by which micro-organisms maintain a single-cell condition may be inhibited without the simultaneous inhibition of other metabolic processes, thus permitting the organism to grow, unchecked, as a filament. Other common properties of the $B \rightarrow F$ and $Y \rightarrow M$ processes, as will be shown, permit the assumption that a comparable mechanism is being affected in the three cases.

Hinshelwood has developed a very convenient concept with respect to the change $B \rightarrow F$ from his studies on the action of proflavine, *m*-cresol, and of the effect of the nitrogen source on bacterial growth. Normal growth is viewed as the result of a balance between a division (D) factor and an elongation (L) factor; the latter factor has been shown to be diffusible. This diffusibility of the elongation factor L was recorded from the property of culture filtrates from *Bact. lactis aerogenes* of hastening the onset of growth, through a shortening of the lag period, when added to culture media; in some instances division did not keep pace, and the process $B \rightarrow F$ resulted. Other methods for disturbing the balance between the division and elongation factors included the incorporation into a nutrient medium of traces of *m*-cresol or proflavine; these agents selectively inhibited division without exerting marked suppressive action on other cell functions, with the result that cultures of *Bact. lactis aerogenes* so treated consisted of tangled masses of long thread-like elements.

While the appearance of the $B \rightarrow F$ phenomena is not markedly apparent with most bacteria in ordinary culture media, the production of the $Y \rightarrow M$ process and the occurrence of $Y \rightleftharpoons M$ among several of the pathogenic fungi are essential characteristics of their identification. It will be well to present at once the reasons for believing that the growth of yeasts by budding and of bacteria by fission may be accomplished in a comparable fashion despite apparent morphological differences between the two modes of growth. At least three rather convincing reasons may be advanced for this view. (1) Budding of yeasts has been shown[27] to exhibit the same mechanical principle (Principle of Least Action) characterizing the growth of other cells with determinate axes (*inter alia*, rod-

* Based on a lecture given at the London School of Hygiene and Tropical Medicine on March 22, 1948.

shaped bacteria), for a yeast bud arises so that its long axis is a tangent to the mother cell at the point of contact. (2) There are genera of yeasts, for example, *Saccaromycodes*, which reproduce by fission, as do bacteria, but which are ostensibly related to other yeasts. (3) As will be shown, certain substances in trace concentrations promote the process $B \rightarrow F$ (and, furthermore, the promotion of $B \rightarrow F$ in Gram-positive bacteria is accompanied by a loss of Gram-positivity); these same substances, in trace concentrations, promote the process $Y \rightarrow M$ and loss of Gram-positivity in yeasts. Having set forth seemingly valid reasons for believing that the division of yeasts and of bacteria result from the action of closely comparable mechanisms, we may proceed with further comparisons.

Among the yeasts, the order Mycotoruloideæ is characterized by the formation of mycelial structures; three genera, *Candida*, *Trichosporon* and *Brettanomyces*, are included in the group. Experimental work pertinent to the discussion has been carried out mainly with species of *Candida*. In this genus there is one species, *C. albicans*, undoubtedly pathogenic for man and experimental animals, together with species of probable pathogenicity, and others that are non-pathogenic. All species exhibit the process $Y \rightarrow M$ under appropriate conditions. *C. albicans* may cause infections of various tissues, including chronic infections of the skin and nails. These latter regions may also be infected by other pathogenic fungi, the dermatophytes; now it is a clinical fact that mixed fungus infections of the skin or nails are rarely encountered. With isolates of *C. albicans* and the dermatophyte, *Trichophyton rubrum*, obtained from nail infections, Jillson and Nickerson[6] attempted to learn if the growth of one fungus could inhibit the growth of the other in culture and thus contribute an explanation for the known clinical situation. Such was, indeed, found to be probable. But the inhibitory effect exerted on *C. albicans* by *T. rubrum* was of a differential type; only the development of mycelial structure, *M*, was inhibited, whereas growth in the yeast phase, *Y*, was not appreciably affected. This *T. rubrum* effect was obtained first in two-membered pure cultures, and later shown to result from the production of two diffusible metabolic products, which have been partially characterized. Recently it has been found that activity in one of the fractions is probably the result of its —SH group content.

Early in the study of the effects of penicillin action on micro-organisms, it was found by Gardner[7] that sub-bacteriostatic concentrations of penicillin induced $B \rightarrow F$ conversions in Gram-negative as well as in Gram-positive bacteria. More recently, the cytochemical investigations of Pratt and Dufrenoy[4] have amply confirmed this point and demonstrated that Gram-positive bacteria become Gram-negative in the process. The latter authors have also made it clear that the probable mode of action of penicillin against Gram-negative organisms is the same as against Gram-positive organisms, in spite of the higher concentrations needed to achieve effects against the Gram-negative group. A very significant point emerging from these researches[4] is the implication of —SH group oxidation with the mode of action of penicillin. In plate inhibition-zone studies with *Staphylococcus aureus*, positive tests for —SH groups were always obtained with cells in the uninhibited regions, but were never obtained in the inhibited zone. The fact that loss of stainability of the Gram-positive complex accompanied the $B \rightarrow F$ process, resulting from penicillin action, also implicates —SH group oxidation, since Henry and Stacey's[8] investigations on the chemical nature of the Gram-positive complex have shown it to be magnesium ribonucleate with associated —SH groups; oxidation to S—S abolished the stainability of the complex. Pratt and Dufrenoy have expressed the view[4] that penicillin exerts its bacteriostatic effect by promoting the oxidation of —SH to S—S, and Cavallito[9] has shown that cysteine can suppress the action of penicillin, presumably by acting as an —SH donor.

The probability that —SH groups represent the active component of one of the *T. rubrum* filtrate factors effecting a suppression of the $Y \rightarrow M$ process may be taken as further evidence of the similarity of cell division processes in bacteria and in yeasts. Similarity in the action of cobalt on penicillin inhibition and on the $Y \rightarrow M$ process further links —SH groups in the two processes. Pratt and Dufrenoy[4] have noted that trace amounts of the cobalt ion Co^{++} increase the sensitivity of micro-organisms to penicillin inhibition. It seems possible that the effect of cobalt lies in its ability to form complexes with cysteine, as shown by the work of Michaelis[10]. In studies on the toxicity of cobalt to yeasts[11], a very sharp break appeared in the curve of growth *v.* concentration of cobalt ion in the region of $M/10{,}000$ Co^{++}. Employing radioactive Co^{56+59}, it was found[11] that most of the activity accumulated in growing yeast cells in one distinct fraction. The activity was retained in the cells during prolonged washing and during ether-acetone extraction, but was removed by cold 10 per cent trichloracetic acid extraction. The Co^{56+59} was precipitable from this extract on standing, after neutralization, as a light, brownish flocculant. Work on the type of binding for the cobalt in this fraction is in progress. The addition of Co^{++} to media, in amounts insufficient to inhibit growth, favours the development of $Y \rightarrow M$ process in yeasts ordinarily existing only in a *Y* form on agar media. *Hansenula anomala* has been particularly examined in this connexion[12,13]. It develops much elongated cells, which tend to remain attached to give an appearance suggesting 'trees', on a malt agar medium with added cobalt ions. Cysteine antagonizes the cobalt ion effect.

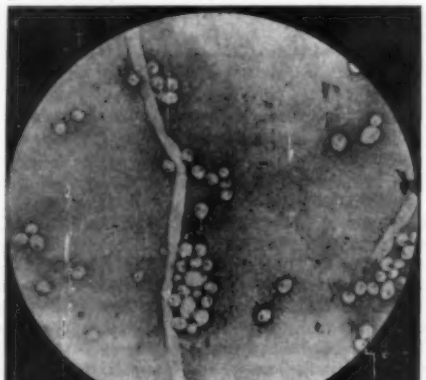


Fig. 1. *Candida albicans* from untreated slide culture on potato agar showing normal production of *Y*- and *M*-forms. Stained with 1 per cent aqueous toluidine blue; distinct nucleus in each *Y*-cell; three nuclei may be discerned along the length of the *M* filament. × 750

Fig. 2. *Trichosporon capitatum* from potato agar slide culture with penicillin (10 O.U./ml.). Toluidine blue staining. Production of two types of *Y*-cells (arthrospores and blastospores) is characteristic of this yeast. Nuclei were spaced at more or less regular intervals for more than 100 μ along the partially drawn *M*-filament

The implication of the —SH group of cysteine in the division processes of bacteria and of yeasts recalls the earlier work of Voegtlin and Chalkley[14] on *Amœba proteus*, of Hammett[15] on *Paramecium*, and of Brachet[16] on the embryonic development of Amphibia. In all this work, a relationship between —SH groups and cell division was strongly indicated. With *Amœba* it appeared[14] that glutathione enhanced the rate of nuclear growth (while cupric ions impeded it), thus speeding cell division, since division occurred regularly at an almost constant nuclear volume. In the experiments of Chalkley and Daniel[17] on *Amœba*, it was found that on the failure of fission processes (experimentally induced) to result in cell division, there remained no 'residual tendency' towards division; the cell was left with two nuclei. Division of one of these was necessary before cell division would again occur. In a general way, this relationship holds with yeasts for $Y \rightarrow M$ processes. Extremely long filaments may be observed with only one or a few nuclei scattered along the length of the *M* growth. With *Candida albicans*, which produces clusters of blastospores (uninucleate *Y* cells) at loci spaced along an *M* axis (see Fig. 1), we may have an example wherein division of an *M*-nucleus results, not in division of the already formed filament, but in intensive localized budding of yeast cells. In other instances (Fig. 2) *M*-elements may be seen with numerous nuclei scattered along the filament. In the $Y \rightarrow M$ process it appears that the normal close association between nuclear and cell division is disrupted so that growth occurs without cell division, while nuclear division may or may not occur.

In the experiments of Hinshelwood on bacteria and of Nickerson *et al.* on yeasts, a very large proportion of the cells exposed to the various division-inhibiting substances were found to have entered an elongated state. Normally, with *C. albicans*, one may observe mycelia production around the entire border of a colony. The very high proportion of cells exhibiting an inhibited division, but uninhibited growth (defined as an irreversible increase in volume, following Went and Thimann[18]), seems to preclude the operation of mutational or survival-selection mechanisms as the basis for the observed phenomena. This is strengthened by the reversible nature of the processes, since filament or mycelial stages may readily give rise to bacterial or yeast forms of growth following the removal of the active chemical agents and transfer to suitable growth media. It seems permissible to regard the inhibition of division as the inhibition of an enzymatic mechanism, which may resume functioning when the inhibiting agents are removed. The effectiveness of proflavine, *m*-cresol, cysteine, and cobalt in trace concentrations against the division mechanism of growing cells favours an enzyme-inhibition concept. The specificity of these substances for the division mechanism of growing cells favours a unit enzyme-inhibition concept.

The argument in favour of a unit enzymatic division mechanism in cells of micro-organisms based on the specific response of cells to trace concentrations of proflavine, *m*-cresol, cobalt, and cysteine may be even more forcefully presented in the case of penicillin. Penicillin, as Dubos[19] has emphasized, does not act as a generalized, non-specific protoplasmic poison; its effectiveness in high dilution favours the concept of attack on specific loci of the cell. Much evidence now points to the action of sodium-penicillin G as operating through a shift toward the right in the —SH $\rightleftharpoons$ S—S functions of the cells; as has been noted, cysteine (—SH) suppresses the action of penicillin. The action of penicillin *in sub-bacteriostatic concentrations* in promoting the process $B \rightarrow F$ is one of the first detectable effects of penicillin. This specificity at extreme dilution is significant. The parallel (see Table) between the general phenomena of the processes of filament formation in bacteria, mycelium formation in yeasts, and penicillin action indicates a common specific functional unit as the sensitive locus in the cell.

Such a unitary enzyme concept is supported by genetic studies on irradiated bacteria (Witkin[3], Lea[20]), and by electron microscope studies of irradiated bacteria (Eisenstark and Clark[3]). Following ionizing radiation of bacterial cultures, Kempster[21] early observed that cells might fail to divide but retained the power of growth since elongated filaments were produced. Haberman and Ellsworth[22] have produced elongated cocci by such procedures, and Witkin[3] obtained greatly elongated cells of *Esch. coli*. The elongations following radiation have generally been observed to be irreversible.

Witkin, employing X-radiation, has obtained permanent $B \rightarrow F$ conversions; her analysis of the dosage-response data indicates a 'one hit–one gene' inactivation. Examination of filaments of *Esch. coli* (X-ray induced) in the electron microscope by

Agents uncoupling cell-division from cell-growth

Compound	$B \rightarrow F$	$Y \rightarrow M$	Gram positivity	Ribonuclease action
Proflavine	promoted[1]	promoted[12]	abolished[12,23]	inhibited[23]
Cobalt	promoted[4,12]	promoted[12]	abolished[12]	
Cysteine	prevented[4,12]	prevented[12]	preserved[12]	
Penicillin	promoted[4,7]	promoted[13]	abolished[4]	inhibited[23]

Eisenstark and Clark revealed 'breaks' spaced periodically along the length of a filament; they put forward the hypothesis that an "enzyme responsible for pinching off the cell wall in normal bacterial fission has been destroyed by rays while other enzyme systems continue to function".

With the group of pathogenic fungi exhibiting the process $M \rightleftharpoons Y$, depending on the temperature of incubation, it has recently been shown by Levine and Ordal[23] and by Nickerson and Edwards[5] that the interconversion of form is solely a function of temperature. The $M \rightleftharpoons Y$ transformations in *Blastomyces dermatitidis* and *B. brasiliensis* are obtainable without difficulty on a simple nutrient medium (consisting of ammonium-nitrogen, inorganic salts and glucose) just as they are obtained on complex media. No growth-factor requirements have been observed for either species of *Blastomyces*, nor have special atmospheric requirements been found to be necessary for the process $M \rightleftharpoons Y$. Since no chemical agent need be added to the cultures to promote the morphogenetic transformations, it seems that effects of temperature on the metabolism of these organisms may be examined more closely for possible clues to its action in the regulation of morphogenesis.

Oxygen consumption seemed particularly important in this regard; respiratory measurements were made on washed, vigorous mycelia over a range of temperature in an ultra-micro respirometer. With intervals of 3–5° over a range from 3–45°, it appeared that plots of rate v. temperature in degrees lent themselves to a separation of two ranges, 3–20° and 20–40°. However, plots of rate v. the reciprocal of absolute temperature gave curves which were slightly concave downwards; no 'breaks' or 'critical points' were noticeable. These data fit well with the recent mathematical formalization for temperature increments in biological processes elaborated by Morales[24] on the basis of the Johnson–Eyring formulation[25] of absolute reaction-rates. In this interpretation, two rate-limiting processes control the observed reaction-rates; at lower temperatures (3–20°) the splitting of substrate-enzyme complexes is rate-limiting, while in the higher range (20–40°) reversible enzymic denaturation becomes rate-limiting. Such a formulation does not imply 'breaks' in the plots of rate v. the reciprocal of absolute temperature. Rather, it leads to curves that are smoothly concave downwards.

No clues of the physiological mechanism underlying the *thermal dimorphism* of *Blastomyces* were obtained from these experiments on the effect of small temperature changes on oxygen consumption. When similar measurements were made on mycelial preparations exposed to large changes in temperature (15° or more) there appeared what is commonly termed 'overshoot', or exaggerated response, phenomena. (It should be pointed out that the process $M \rightarrow Y$ is obtained with these organisms following the transfer of a mycelial culture from room temperature to the 37° C. incubator—a jump of more than 15° C.) Following an abrupt increase from 5 to 20°, the rate of oxygen consumption was briefly higher than expected for the 20°-level, following which it rapidly recovered to the normal rate for the indicated temperature. (The brief higher level is not an artefact of technique.) An increase from 20° to 40° resulted in a tremendously increased rate of oxygen consumption that slowly levelled off to the rate anticipated for 40° C. If we view the rate of oxygen consumption as normally being determined in the range 5–20° by a constant k_1, which is a measure of the rate of enzyme substrate splitting and, in the range 20–40°, as the result of two simultaneous rate-limiting phenomena k_1 and k_2 (the constant for a reversible enzyme denaturation), we may write the following expression:

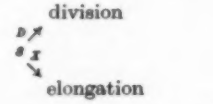
$$5° \xrightarrow{k_1} 20° \underset{k_2}{\overset{k_1}{\rightleftharpoons}} 40°$$

where the arrow to the right indicates increasing velocity of reaction and that to the left (←, denoting reversibility) indicates a decreasing effect on velocity. Since at any given temperature in the range 20–40° the rate of oxygen consumption is constant for many hours, we may conclude that k_1 and k_2 have achieved a steady state. The large, abrupt increases in temperature upset this steady state to produce a situation which may be expressed by:

$$20° \underset{k_2}{\overset{k_1}{\rightleftharpoons}} \xrightarrow[\text{change of } >15°]{\text{abrupt}} \left[40° \underset{k_2}{\overset{k_1}{\rightleftharpoons}} \right] \xrightarrow{\text{time}} 40° \underset{k_2}{\overset{k_1}{\rightleftharpoons}} \text{(gradual restoration)}$$

The temporary apparent suppression of the rate-limiting factor k_2 is deduced from the overshoot in oxygen consumption. That this 'apparent suppression' probably results from measurable difference in the speeds with which the two rate-limiting processes return to equilibria is seen from the difference in times required for the reappearance of a steady state at 20° and at 40° after large jumps to these temperatures.

In view of the fact that the other aspects of the metabolism of *Blastomyces* investigated thus far, other than oxygen consumption, are comparable for the yeast and the mycelial forms, we are inclined to attach importance to the results for respiration, in the sense that they may indicate the physiological basis for the observed thermal dimorphism. We may conceive that the cell division enzyme complex (D) lies at the end of a chain of consecutive reactions which produce its substrate (s); it is further conceivable that (D) must compete for (s) with another enzyme complex (X) which is concerned with cell elongation.



Let (s) be produced by reactions for which the rate-limiting processes are only of the enzyme-substrate splitting category, and assume that (X) has a higher affinity for (s) than has (D). Under such conditions, elongation will result and division will be suppressed. If, for the reaction $s \xrightarrow{X}$ elongation, the rate-limiting factor is the reversible denaturation of (X), it may be possible for the reaction $s \xrightarrow{D}$ division to predominate at higher temperatures. In view of the lag in 'adjustment' of the process in respiration which probably is rate-limiting by reason of its reversible denaturation, we might say that a parallel phenomenon, operating in a growth mechanism of the type conjectured, would result in a supply of (s) saturating (X), thus permitting an initiation of the (D) reaction.

The actual nature of *D*, *X* and *s* (and definitive evidence for their existence) must be left for future investigations. In view of Hinshelwood's implication of the importance of the source of nitrogen for the $B \rightarrow F$ process in *Bact. lactis aerogenes*, and earlier work of Langeron and Guerra[36] along similar lines for the $Y \rightarrow M$ process in *C. albicans*, we may see indications of the nature of (*s*). Viewing elongation as 'straight growth' and division as 'curved growth', it may reasonably be imagined that 'rigid' or 'flexible' molecules resulted respectively from the action of *X* or *D*. In this connexion the recent investigations of Jeener[37] and Lyons[34] on the fibrinogen – fibrin proteins are suggestive; the critical importance of —SH ⇌ —S—S— in this process makes it even more suggestive, since —SH maintenance inhibited fibrin formation, and —SH donors maintain spherical growth of yeast cells. The analogy between maintenance of cell division and the prevention of disulphide-link formation in a fibrous protein may actually be far more than a superficial one. As Astbury[35] has so fascinatingly written, ". . . the molecular plan of the keratin–myosin–fibrinogen group is one of the great primal ideas in vital architecture. . . . It represents a fundamental power of the cell of synthesizing elastic fibrous protein of a standard molecular form, yet whose details can be adapted to a variety of ends as the processes of differentiation demand." The ability of a cell to grow may then reside in its ability to form elastic fibrous protein, and its ability to divide may reside in its potential to prevent the formation of intermolecular disulphide links and resultant loss of molecular elasticity. Such a concept of cell division is, in fact, reminiscent of that elaborated by Rapkine[36] several years ago, who held that cell division is accompanied by configurational rearrangements of cell protein resulting in an increase in the appearance of protein —SH groups.

In view of recent work[28] on the mechanism of action of acridines (proflavine, trypaflavine), we may consider some relationships of nucleic acid metabolism in $Y \rightarrow M$ phenomena. Acridines are believed to exert their growth- (and respiration-) inhibition effects by union with nucleoproteins of the cell[28]; this inhibition may be overcome by addition of nucleic acid[29,30]; nucleic acid-proflavine complexes have been prepared[30]. It is clear that the ribose nucleic acid content of cells that have undergone the $Y \rightarrow M$ process is greatly lowered; they are Gram-negative, and are stained scarcely at all by pyronin from the Pappenheim–Unna mixture. Yet these cells have grown and undoubtedly synthesized protein. Populations of elongated cells may be grown (excluding the possibility of 'redistribution' from the *Y* form) which are pyronin 'negative'[13]. Spiegelman and Kamen[31] have recently queried the correlation between nucleic acid metabolism and protein synthesis. Results from the study of the $Y \rightarrow M$ and $B \rightarrow F$ processes *appear* to augment their query. But if particular types of protein synthesis (and maintenance of elasticity) are involved in division processes, it may be that it is with these that nucleic acid metabolism is associated[16] during normal growth and cell division.

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PHYSICAL PROPERTIES OF SUBSTANCES OF HIGH PERMITTIVITY

ON June 12, the Electronics Group of the Institute of Physics held a symposium on substances of high permittivity, the so-called ferro-electrics. Three papers were followed by a discussion. Original results were reported by speakers both in the last two papers and in the discussion—a sign of the considerable interest shown.

A survey of the electrical and crystallographic background of ferro-electricity was given by Dr. Vera Daniel (British Electrical Research Association). She pointed out that the essential feature of ferro-electric materials is that they consist of domains with a spontaneous electric polarization. With no external field and in equilibrium, the moments of these domains cancel each other. The effect of a field on a specimen of such a material is two-fold. It influences the polarization of each domain and it may also reverse the polarization of domains. The spontaneous polarization of an individual domain is an equilibrium property, and at any given temperature the differential of this polarization, with regard to field strength, defines an 'equilibrium' permittivity. The permittivity of a real specimen is made up of this equilibrium permittivity plus a contribution due to the reversal of domains. The latter contribution is necessarily very sensitive to structure and implies the existence of saturation effects; for if already all domains are aligned in the direction of the field, no further domains can be reversed. The reversal of domains also leads to hysteresis.

All ferro-electric materials are crystalline, and from the point of view of the crystallographer their properties

imply unusual conditions. It is not rare for crystalline substances to have a spontaneous polarization; but in the majority of cases this does not depend appreciably on electric field strength, and domains cannot be reversed by a field. It is quite exceptional that the forces controlling the polarity are as weak as to be comparable with the energy of an applied field, which is the case for ferro-electrics. All known cases of ferro-electricity are connected with the change of a structure with spontaneous polarization into one without such polarization. These changes occur gradually over a temperature interval, the spontaneous polarization decreasing more and more rapidly on approaching a critical temperature, called the Curie point in analogy with ferro-magnetism. Thermodynamically, the change of structure may be a first- or second-order transition. The Curie point is associated with a sharp peak of the permittivity.

Dr. Daniel concluded by discussing experimental and theoretical work done on Rochelle salt, potassium dihydrogen phosphate and ferro-electrics of similar structures. Ferro-electric properties depend on very delicately balanced energy conditions, and their understanding presupposes a very thorough knowledge of the bonding of the crystal structure. It seems remarkable how much progress has been achieved in spite of the difficulties of the subject, even with regard to so complicated a substance as Rochelle salt[1].

Dr. D. F. Rushman (formerly of Philips Electrical, Ltd.) discussed the high permittivity titanates, such as barium titanate and its solid solutions with the titanates of other metals of the second group of the periodic system of elements.

These ceramic materials, the unusual electrical properties of which were discovered during the War, have considerable practical interest. In practice, barium titanate is prepared from barium carbonate and titanium dioxide at temperatures higher than 1,000° C. To form a dielectric it is crushed, sieved, and sintered at about 1,300° C., clay or other binder being added in small quantities, to reduce the porosity. The preparation is not simple, and care is required to produce a material of uniform quality. Dr. Rushman showed the effect of wrong firing conditions on the dielectric properties.

Dr. Rushman discussed in detail the experimental evidence which establishes the ferro-electric character of barium titanate and some of its solid solutions with other titanates. The permittivity-temperature curve shows a characteristic peak at the Curie point[2]. Saturation effects are shown very strikingly by the fall of the permittivity when the specimen is in a strong D.C. field, and the materials give characteristic hysteresis loops. It is possible to produce electrets, that is, specimens can be polarized and the polarization 'frozen in', producing a specimen analogous to a permanent magnet. The crystal structure[3] is tetragonal, with spontaneous polarization[4], in the ferro-electric temperature region and cubic, without spontaneous polarization, above the Curie point. The structural transition at the Curie point is curious in that the cubic and tetragonal phase co-exist over a temperature range of a few degrees. The specific heat has a λ point at the Curie temperature, a characteristic feature of ferro-electric and ferro-magnetic materials[5].

Dr. A. S. Devonshire (University of Bristol) dealt with the theory of dielectrics and ferro-electricity. He gave an account of original theoretical work on some features of ferro-electricity, and in particular on the spontaneous polarization in barium titanate.

The permanent polarization in titanates can be explained, Dr. Devonshire said, by the forces between electric dipoles. If a substance containing dipoles breaks up into long narrow domains polarized along their length and the net polarization is zero, the mutual potential energy of the dipoles is $-\frac{4}{3}\pi P^2$ per unit volume, where P is the polarization per unit volume. When an ionic crystal is polarized, it contains a set of pseudo-dipoles, formed by displacement of the ions. If the energy required to displace the ions is less than $\frac{4}{3}\pi P^2$, the polarized state will be the most stable one; that is, there will be a spontaneous polarization. Dr. Devonshire here directed attention to a difference between ferro-magnetism and ferro-electricity. The interaction between electric dipoles is a long-range force, that is, the force on dipoles is partly due to dipoles in distant parts of the domain. In contrast, the forces which orient the magnetic dipoles in a ferro-magnet are almost entirely forces between nearest neighbours; the long-range forces are relatively very small.

The ferro-electric properties of barium titanate are due to the structure having a spontaneous polarization at temperatures below the Curie point. Dr. Devonshire classified the effect of temperature on the spontaneous polarization under three headings: (1) Thermal expansion decreases the number of dipoles per unit volume. This means a decrease of polarization with temperature. (2) Thermal expansion decreases the restoring force on a displaced ion. This means an increase of polarization with temperature. (3) Thermal oscillations tend to decrease the polarization with increasing temperature. The first of these effects is relatively small. The second two effects have opposite sign, but the same order of magnitude, and it is not possible to predict on theoretical grounds which predominates. Experiment shows that the polarization disappears at high temperatures. Hence the third effect must be larger than the second.

The potential energy of the system is further decreased if the crystal expands along the direction of polarization so that it becomes more polarizable in that direction. This interaction between structure and polarization has the effect of increasing the change of polarization with temperature and accounts for the transition at the Curie point being of the first and not of the second kind.

In the discussion, Dr. Rushman directed attention to some properties reducing the practical usefulness of titanates. One of these is their relatively low breakdown strength. Owing to the minimum thickness required for mechanical reasons, this is no serious disadvantage unless voltages above 500 V. are used. Another disadvantage is the fact that the titanates, being ceramics, cannot be used in such thin layers as dielectrics like paper. The marked dependence upon temperature of the permittivity is also a drawback for general use. Dr. Rushman observed that in general a ferro-electric material can never be a really stable dielectric because its ferro-electric properties are due to a certain instability of its structure. Nevertheless, the high permittivity of the titanates makes them useful dielectric materials for special purposes.

Dr. H. F. Kay (University of Bristol) contributed data indicating the way in which domains in barium titanate single crystals are arranged. Domain boundaries follow 101 or 011 planes, and the domains are

often laminar. Dr. Devonshire pointed out that this need not contradict his postulate that for the most favourable conditions of potential energy domains should be elongated. The large domains found optically may be subdivided into smaller domains of equal c direction but different direction of polarization. Dr. Kay then showed that the structural changes in barium titanate and solid solutions of barium and strontium titanate can be explained with surprising accuracy if one assumes the barium and oxygen ions to be rigid spheres with the conventionally accepted ionic radii. This assumption even gives the right value for the spontaneous polarization. However, as Dr. Kay pointed out, the physical meaning of the changes could scarcely be so simple.

Mr. M. G. Harwood (Philips Electrical, Ltd.) reported experimental results regarding the lattice parameters of the tetragonal, ferro-electric form of barium titanate over a wide range of temperature, directing particular attention to changes which occur at points below room temperature, where other workers had previously found anomalies in the dielectric properties. The axial ratio c/a, although on the whole increasing steadily with decreasing temperature, shows discontinuities at approximately $+5°$ and $-70°$ C., a sudden drop in the ratio being recorded at each of these temperatures. This was analysed in terms of anomalous changes of the lengths of the tetrad and diad axes, which at all other temperatures vary in a continuous and regular manner. X-ray and optical examination shows that at these two particular temperatures, where two structures co-exist over about 10° C., the domains change their direction of polarization in the absence of an applied electric field. The reason for this still awaits an explanation; but it may account for the peaks in permittivity at these points.

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GEORGE STEPHENSON, 1781-1848

ON August 12, 1848, a century ago, George Stephenson died at his home, Tapton House, Chesterfield, at the age of sixty-seven, and was buried in Trinity Church in that town. For some years he had been more concerned with his properties than with railways, taking special delight in horticulture and his Derbyshire collieries. His father had been a fireman at a Northumberland coal mine, and Stephenson himself had passed his boyhood amidst coal pits, pumping and winding engines. He had become an assistant fireman when fifteen, was the mechanical engineer at Killingworth Colliery at thirty-one, built his first colliery locomotive at thirty-three; his first railway was that laid down at Hetton mines a little later, and the famous Stockton and Darlington Railway, of which he was the engineer, was designed primarily for mineral traffic. His interest in collieries was therefore life-long.

The story of Stephenson's rise from obscurity to fame is a familiar one in industrial history. Born in the lowliest circumstances, he enjoyed none of the early advantages of Watt or Smeaton or Rennie, and it was only when eighteen, through his own perseverance and industry, he learnt to use a pen and entered the magical world of books. His mechanical ingenuity, however, was evident from the first; and it was only a year after he constructed his first locomotive, *Blucher*, that he devised the 'Geordie' miners' safety lamp, for which he was given £1,000 by his fellows. The reputation thus gained was increased by his success at Hetton, and at a time when the mechanical world was divided over the respective merits of horses, stationary engines and 'travelling engines' for industrial railways he was able to prevail upon the Darlington manufacturer, Edward Pease (1767–1858), to use locomotives, except for steep inclines, on the Stockton and Darlington line.

Moreover, through the confidence Stephenson inspired, he was enabled to secure the co-operation of Pease and others in founding the first locomotive-building works in the world. Set up at Newcastle in 1823, under the title R. Stephenson and Co., the firm supplied many of the most famous of all early locomotives. George Stephenson was then in his 'forties, his son Robert in his 'twenties, and it is impossible to dissociate the work of one from the other. Generally it may be stated that the period 1820–25 saw the construction and opening of the Stockton and Darlington Railway and the period 1825–30 the construction and opening of the much more important Liverpool and Manchester Railway, on which in 1829 took place the epoch-making Rainhill locomotive trials, which decisively placed the steam locomotive in the position of supremacy.

Needless to say, the steam railway would have come if George Stephenson had never lived; but it was his good fortune to be in the current of affairs at a critical time, and to be endowed with both the mental and physical characteristics necessary for the task which lay ahead. The locomotives of Trevithick, Hedley and Blenkinsop had preceded Stephenson's, while railroads or tramways had been in use a very long time. Then, too, many men, without any claims as inventors or engineers, saw what was possible, and their views were shared by men of high commercial standing. Before the Stockton and Darlington Railway was started and before Stephenson's factory at Newcastle was opened, in 1820 Thomas Gray, who died in poverty two months after Stephenson passed away, published his little book entitled "Observations on a General Iron Railway", which ran through five editions in five years, and contained plans for trunk lines from London to Falmouth, Dover, Edinburgh, Holyhead, etc. Still other promoters were William James, Nicolas Wood, the mining engineer, and Charles Maclaren, the editor of *The Scotsman*.

By this time the advancement of civil engineering and mechanical engineering in the eighteenth century had given Britain great constructional works and engine shops, the supply of iron for rails, boilers and engines was ample and many men were ready to follow in the footsteps of Stephenson. His lines and his shops, too, provided the training grounds for the future railway engineers, and so it was that with the completion of the Liverpool and Manchester Railway the great era of railway construction began. In Great Britain alone, by 1840 there were more than 800 miles of lines open, by 1860 more than 10,000 and by 1880 some 18,000 miles. Not a single engineer of those days would have denied that the world was entitled to regard George Stephenson as the 'father of railways'.

NEWS and VIEWS

Sir Francis Darwin (1848 1925)

THE third son of Charles Darwin gave early evidence of a scientific bent. Born at Down a century ago, on August 16, 1848, he took his degree at Cambridge in 1870 with a first class in the Natural Sciences Tripos. After studying medicine at St. George's Hospital, London, and obtaining the Cambridge M.B. in 1875, he acted as his father's secretary for eight years. In 1884 he was appointed lecturer, and four years later reader, in botany at Cambridge. At that time plant physiology was beginning to supersede the study of systematic botanical description. Francis Darwin's class-book "The Practical Physiology of Plants" (1894) went into several editions, for it was the first book of its kind in Britain. His researches on growth curvatures in plants and on the control of water-loss by plants attracted considerable attention. He was a popular lecturer, being engagingly simple and direct. Though possessed of strong prejudices and inclined to be intolerant, his was a lovable personality, charming, kindly and humorous. He was an accomplished musician and devoted to dogs, which, unlike human beings, never bored him. Many honours came his way. Elected a fellow of the Royal Society in 1882, he was foreign secretary during 1903–9 and vice-president in 1907. In the following year he became president of the British Association, and he was knighted in 1913. He died at Cambridge on September 19, 1925. It is appropriate that his best and best-known book should be the "Life and Letters of Charles Darwin" (1887).

Statistics of the Ministry of Labour and National Service

THE standing Interdepartmental Committee on Social and Economic Research was appointed in January 1947 to survey and advise upon research work in Government departments and in particular to bring to the notice of departments the potential value for research purposes of the material which they collect, and to suggest new methods and areas of collection. It has also to advise on how there could be made available to research workers information gathered for their own purposes by the departments which has potential value as material for research. The Committee has selected as the first major department for survey (London: H.M. Stationery Office. 9*d*. net) the Ministry of Labour and National Service, which has a tradition of co-operation with research workers. The first results of this survey have been published as a booklet which describes the development of the Ministry of Labour's Statistical Service and the information at present collected by the Ministry on employment and unemployment, wages, earnings, hours and industrial relations, retail prices and family budgets, the changes which have occurred in the form of collection and the effect upon the comparability of successive statistics. In addition to a list of published sources of information, there is included a subject index to published sources of Ministry of Labour statistics. The booklet is experimental in form; but it is hoped that it will prove of value to teachers and students in the universities as well as to other research workers, and criticism and suggestions for improvement will be welcomed by the Committee.

Marconi Transmitters for East Africa

A NEW system of short-wave radio communication is planned in East Africa, where a total of forty-eight Marconi short-wave transmitters are to be installed to provide a comprehensive communications network for ground-to-air and point-to-point communications for the rapidly expanding civil aviation services—both local and trunk routes—and for administrative, public and meteorological traffic. The new services, which will operate throughout the three territories of Kenya, Uganda and Tanganyika, are required to meet the needs of post-war expansion and re-organisation of the East Africa Posts and Telegraphs Department's Services. Two of the latest types of Marconi transmitters have been chosen for this new service. They are Type *TGS*. 541—a 200-watt transmitter with a frequency range of 1·5–23 Mc./s., and Type *TGS*. 501—a 100-watt set covering a frequency range of 1·5–13 Mc./s. Both types of transmitter are compact, easily operated equipments designed for operation on radiotelephony or telegraphy. Special features include crystal-control with provision for the rapid selection of any one of six working frequencies —a particularly useful asset where a large volume of traffic is handled. Frequency tolerances are well within the very fine limits laid down by international regulations. Work has already begun at the Marconi Company's Chelmsford Works on the construction of the first of these tranamitters which are to be installed at Mbeya Airfield, Tanganyika.

Quarterly Journal of Mechanics and Applied Mathematics

THIS new journal is intended to provide a medium for the publication of papers on classical mechanics and mathematical techniques. The first number, dated March 1948, which has recently been issued, contains papers by D. C. Pack, R. Hill, D. R. Hartree and S. Johnston, W. G. Bickley, S. Goldstein, A. D. Young, M. J. Lighthill, and Sir Geoffrey Taylor. Rather more than half of these papers deal with hydrodynamics and its applications to aerodynamics or internal ballistics; the others deal with elasticity or methods and results useful in computation. The editors are Prof. G. C. McVittie and Prof. V. C. A. Ferraro, assisted by an editorial board which includes most of the leading British applied mathematicians. The publishers are the Oxford University Press, and the subscription is £2 a year for the four numbers.

Earthquakes during June

DURING June there occurred at least nine world-shaking earthquakes and a great number of smaller ones. The greatest two of the month were that on June 28, which caused heavy casualties and severe property damage in and around Fukui, West Honshu, Japan (*Nature*, July 10, p. 57) and which gave ground amplitudes at Durham of 115μ, and that on June 30, which caused casualties and property damage on the island of Levkas and the nearby mainland of Greece, and gave ground amplitudes of 220μ at Kew. The other great shocks were on June 15 near the southern coast of Honshu, Japan; on June 18 in the Solomon Islands region; on June 21 in the Celebes Sea; on June 27 (2) off the northern coast of Honduras and south of the Alaska Peninsula; and on June 29 (2) in the Samoan Islands region and in Transcaucasia. An earthquake only slightly less intense occurred on June 13 from a focus the epicentre of which was near lat. 43° 31′ N., long. 12° 8′ E. This caused some property damage and at least one death at San

Sepolcro in the Italian Province of Arezzo. Also during the month there was a swarm of earthquakes in the Karlsruhe, Rasstat, Lauterbourg area. The swarm began on June 1 and lasted practically the whole month, the greatest shock of the series being felt on June 7 with scale VI to VII (some chimneys down) at Karlsruhe. The epicentre of this shock was near lat. 49° 04′ N., long. 8° 19′ E. some 9 km. north-west of Karlsruhe, and the depth of focus has been estimated at 20–30 km. The energy of the shocks of this swarm did not travel far, but was recorded by the seismographs at Strasbourg, Stuttgart and the Swiss observatories. Apart from the observatories mentioned above, reports for the month have also been received from the U.S. Coast and Geodetic Survey, Aberdeen, Beograd, Cleveland (Ohio), De Bilt, Toledo and Uccle.

Galactic Noise

R. v. D. R. Woolley has discussed in a recent paper (*Mon. Not. Roy. Astro. Soc.*, **107**, 3; 1948) the theory of the origin of the galactic radiation. Since radio workers consider it short-wave radiation and spectroscopists regard it as very long-wave radiation, it is undesirable to refer to it by a name embodying any idea of wave-length, and the appropriate term 'noise' has been adopted since it can be heard on the earphones. Eddington discussed the temperature of interstellar space in "The Internal Constitution of the Stars", and estimated it at about 10,000°; but later he suggested that the absorption in space of ultra-violet quanta would reduce the temperature. (By temperature he meant the parameter appearing in the Maxwellian velocity distribution of the free electrons.) Woolley investigates the problems of temperature and the degree of ionization in interstellar space, and concludes that if the noise is due to free-free transitions, it must certainly come from hot regions in interstellar space and almost certainly from regions where the density is above the average. In these circumstances, if 'cold' regions, that is, regions of low hydrogen ionization, do not contribute appreciably to the noise, then an observed amount of galactic noise from a particular part of the sky implies a minimum bright hydrogen emission from that part. If observation fails to reveal this bright hydrogen emission, the only conclusion is that galactic noise is not due to free-free transitions. If the noise is due to free-free transitions, it is shown that the minimum number of $H\alpha$ quanta received per sq. cm. per second per unit solid angle of the sky is within reach of observation with modern equipment.

Cinematograph Films of Living Cells

C. C. Speidel (*Amer. Scientist*, **36**, 237; 1948) describes with some very fine illustrations the results he has obtained by fast cinematography of cells inside the living animal. He used regenerating tail tissue of the tadpole for his observations, and shows that cellular organisation may be studied here with results which tissue cultures cannot provide. Regeneration of nerve fibres, showing the manner in which their direction and anastomosing take place, mitosis in a nerve cell and the relative movements of the two daughter nuclei, the movement of lymphocytes and diapedesis of leucocytes are among the many beautiful results of this method of observation. The salvaging of extravasated blood cell by cell by the sprouting of a lymph vessel is startling, while the movement of muscle fibres in contraction and relaxation may be followed step by step. It would seem that this method of analysis would be of great value in further studies of development, especially in the little-known differentiation of plant tissues.

Tests of Mosquito Repellents

When Australian forces began campaigning during the Second World War in the highly malarious islands of the south-west Pacific area, a very urgent need was an effective mosquito repellent. Bulletin No. 213 (1947) of the Commonwealth of Australia Council for Scientific and Industrial Research describes laboratory and field tests conducted by Major R. N. McCullough and Capt. D. F. Waterhouse with this object in view. More than 125 substances were tested for use as repellents against both anopheline and culicine mosquitoes. The chief species used in these experiments were *Anopheles punctulatus farauti*, the yellow-fever mosquito *Aedes ægypti*, and the common pest mosquito *Aedes vigilax*. The work involved was a co-operative investigation between the Council for Scientific and Industrial Research and the Army. Taking all factors into account, dimethyl phthalate was by far the most satisfactory repellent tested. Also, it is almost completely odourless and has very little or no irritant effect on the skin of the hands and face, to which it is applied. A number of other synthetic and naturally occurring substances were tested with indifferent results. Many essential oils were quite ineffective, while the two most promising were too irritant to use. Pyrethrum preparations gave consistently poor results. The treatment of clothing with dimethyl phthalate prevented mosquitoes from attacking through the material, except to a very limited degree, up to 72 hours after application. As a result of these investigations of repellents, and of those on a larger scale in the United States, the manufacture of adequate quantities of dimethyl phthalate was organised and the substance made available to the Australian fighting forces in 1943, some special forces being supplied with it as early as March 1943.

Control of Weeds

Prof. G. E. Blackman, in a short paper on "Recent Developments in the Control of Weeds" (*J. Roy. Hort. Soc.*, **73**, 5; May, 1948), summarizes some useful results on the effectiveness of various selective weed-killers. Sulphuric acid gave the best control of goosegrass, *Galium aparine*; methyl-chloro-phenoxy-acetic acid gave the best kill of shepherd's needle, *Scandix pecten-veneris*, and common red poppy, *Papaver rhœas*; and dinitro-*ortho*-cresol was most toxic to scentless mayweed, *Matricaria inodora*, but also gave control equal to the acetic acid compound of *P. rhœas*. The use of sulphuric acid is still most effective, particularly against weeds of the onion crop. Spraying with this acid gives about 90 per cent of the yield obtained by hand weeding and hoeing, but at very much less expense in labour. Charlock is susceptible to control by growth-substance sprays at all stages from seedling to flowering, though poppies are susceptible only as seedlings.

Tomato Spotted Wilt Virus

The disease of tomatoes caused by spotted wilt virus often shows considerable variation in severity. D. O. Norris has now shown (Bull. 202, Coun. Sci. and Ind. Res., Australia; Melbourne, 1946) that this is due to varying combinations of at least five strains of the virus. The paper describes and figures the

symptoms of these strains on sixteen host species, and indicates suitable tests for the presence of strains in a particular disease. The thermal death-point of spotted wilt complexes is considered to be about 10° C. higher than the usual value of 42° C. This is a rather unwelcome discovery from the point of view of possible control. On the other hand, the finding of a high degree of resistance to spotted wilt by *Lycopersicum peruvianum* is likely to be of considerable importance in breeding.

Clutch and Brood-size in the Robin

THE inquiry into clutch and brood-size in the robin (*Erithacus rubecula*), which was first reported by David Lack in 1946, has now been closed. Later observations show that the breeding season in Holland is later than in Britain but is earlier in North France, Germany and Switzerland than inland in Europe at a similar latitude (*British Birds*, **41**, No. 4; April, 1948). The tendency for the average clutch-size of the robin in England and Wales to be highest in May, lower in April, and lower still in March, June and July has been confirmed It has also been shown that the average clutch-size is different in different years and there may be a correlation between fine weather and higher clutch-size. The average clutch-size in Ireland is approximately the same as in England and Wales, but in Scotland the average clutch-size is higher than in England and Wales. Nesting is more successful in May than in April, possibly because in April the ground vegetation is not so well grown as in May, leaving the nests less exposed to predators.

International Committee for Bird Preservation

THE report of the British Section of the International Committee for Bird Preservation (The Secretary, c/o British Museum (Natural History), Cromwell Road, London, S.W.7) is a record of much good work. For some years past naturalists and others have been perturbed by the decline in the wildfowl population of the world, and, among other things, the report contains an account of the Committee's work in investigating the situation as it affects the wildfowl of Europe. Among the activities are the ringing of duck to trace their migration routes. A duck decoy at Orielton is being used for this purpose, and ringing on a lesser scale is being carried out at other decoys in Great Britain. In 1947, the headquarters of the Committee, previously in Brussels, were transferred to London, and the British Museum (Natural History) is now the centre of the organisation, which has thirty-four national sections from all five continents.

The Film in Scientific Research

THE Sciences Committee of the Scientific Film Association is arranging a one-day conference on "The Film in Scientific Research", to be held on October 12 at the Royal Institution, London. The chair will be taken by Mr. J. E. Cummins, chief scientific liaison officer in London of the Australian Government, and the Conference will be opened by Sir Robert Watson-Watt. The Conference will include discussions by British and foreign men of science on the value of scientific films as a research tool in various branches of science; the function of the research film in giving up-to-date information in a particular field; scientific films as an aid to the training of scientific workers; scientific films as a medium for explaining to the general public important results of scientific research; and technical aspects of the use of films in scientific research. The Conference will conclude with a two-hour showing of British and foreign research films. Material suggested for discussion and information as to the existence or availability of research films suitable for showing at the Conference should be sent to the Honorary Secretary, Sciences Committee, Scientific Film Association, 34 Soho Square, London, W.1, as soon as possible.

Announcements

WE regret to announce the following deaths:

Mr. S. G. Brown, F.R.S., known for his work on the gyroscopic compass and numerous other mechanical instruments, on August 7, aged seventy-five.

Mr. Harry E. Burton, principal astronomer and head of the Equatorial Division of the U.S. Naval Observatory from 1929 until June 30, 1948, on July 19, aged seventy.

Mr. J. R. Cowie, chairman of Council of the British Electrical and Allied Industries Research Association, on August 5.

Dr. Henry Guppy, C.B.E., librarian of the John Rylands Library, Manchester, on August 4, aged eighty-six.

THE chairman of the Royal Society's Library Committee, Prof. E. N. da C. Andrade, has accepted an invitation by the Council to become honorary librarian to the Society during his tenure of chairmanship of the Library Committee.

SIR LEWIS FERMOR, director of the Geological Survey of India during 1932–35, has been elected *Correspondant Etranger* of the Société Géologique de France.

SIR FRANK STOCKDALE, chairman of the Colonial Development Corporation, has been appointed chairman of the governing body of the Imperial College of Tropical Agriculture, in succession to Sir Eric Macfadyen, who has been associated with the College since 1928.

MR. SETON LLOYD, technical adviser to the Directorate of Antiquities in the Government of Iraq, has been appointed director of the British Institute of Archæology at Ankara in succession to Prof. J. Garstang, as from March 1, 1949.

MR. R. MCCHLERY, former Rhodes scholar and, since 1926, a member of the Agricultural Department, Salisbury, has been seconded to the Central African Council to take up the new appointment of Central African Scientific Liaison Officer in the United Kingdom, and to establish a Central African Scientific Liaison Office in the British Commonwealth of Nations Scientific Offices, London.

DR. A. E. A. WERNER has recently joined the staff of the National Gallery, Trafalgar Square, as research chemist. He was previously reader in chemistry in Trinity College, Dublin.

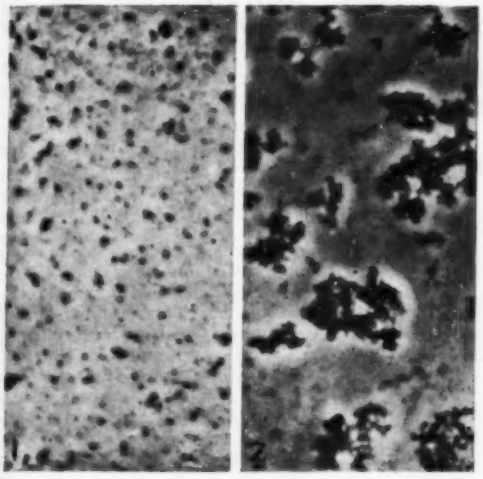
A CONFERENCE of German Hygienists and Microbiologists is being held at Stuttgart during August 25–27. Among the topics to be discussed are: tuberculosis in animals and its chemotherapy; immunization against virus diseases; milk hygiene in Germany; human helminthiasis and its chemotherapy; human and animal trichinosis; rickettsia toxins; morphology and ecology of bacteria; bacteriology of enteritis; serum reactions, etc. Particulars can be obtained from Prof. G. Lutz, Heusteigstr. 66, Stuttgart-S.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Phase-Contrast Microscopy of Viruses

THOSE who have used phase-contrast microscopy will have been impressed by the apparent high resolving power of the method. It is frequently possible to observe very fine fibrils and particles with a clarity hitherto only obtained by dark-ground illumination. Thus, I have observed living *Leptospira*, said to be only 0·15 μ in width, as well as very small granules inside bacteria.



It was to be expected, therefore, that at least the larger viruses would be visible by phase-contrast illumination, and this has now been verified. Fig. 1 shows a smear of psittacosis virus (× 1600), and Fig. 2 one of vaccinia (× 1600). The preparations were unstained and mounted in water. It is important to distinguish between *visibility* and *resolution* of the particles. The photographs were taken with commercial (Cooke, Troughton and Simms) equipment, using an oil immersion lens, rated N.A. 1·3 with phase-ring diameter approximately two thirds of the aperture. The expected resolution under these conditions, using green light, would be of the order of 0·3 μ. One would thus scarcely expect to obtain a true resolution of virus particles; but that does not preclude the possibility of detecting their presence. Thus, the vaccinia particles seemed spherical, not barrel-shaped, as in the electron microscope. The latter appearance may, of course, be due to a drying artefact.

As a rough approximation, it would be expected that particles below the limit of resolution would appear to remain about the same order of size, but would have less contrast, appearing in shades of grey instead of black. The visibility of small particles in the phase-contrast microscope depends on contrast, which is in turn governed by the refractive index of the particles and by the characteristics of the apparatus. Leaving aside the possibility of improving contrast by variation of the refractive index of the mounting medium, perhaps the most hopeful method of increasing the visibility is by alteration of the phase, and particularly the amplitude, characteristics of the phase plate. Given favourable material, there is probably no reason why much smaller viruses should not be seen, using a strongly absorbing phase plate with an intense light source.

It remains to be seen how useful the method will prove in virus research. It is valuable in that it allows fresh unstained material to be used; but it is, of course, non-specific and there is no simple means of distinguishing viruses from other small particles. An obvious application is to the study of the development of virus bodies in living cells.

I wish to thank Prof. S. P. Bedson for supplying the virus material.

ROBERT BARER

Department of Human Anatomy,
Oxford.
July 10.

Experimental Hydronephrosis Studied by the Colchicine Method

THE colchicine method was first used to study compensatory hypertrophy of the kidney by A. P. Dustin and S. Zylberszac[1,2], who noticed that a few days after ligation of the ureter, colchicine induced numerous 'stathmocineses' (arrested mitoses) in the kidney (Fig. 1).

This phenomenon has been reinvestigated in the adult rat, nine hours after injection of 2·0 mgm./kgm. of colchicine, mitosis being counted in the obstructed and the opposite kidneys. The total number of divisions was counted in median sections and, in order to compare the figures more accurately, these were corrected per 100 gm. of animal weight (Fig. 2).

In the obstructed kidney, two days after ligation, numerous stathmocineses are found in the interstitial cells, convoluted tubules, loops of Henle, distal convoluted tubules and collecting tubules. None is seen in the glomeruli. The mitoses remain numerous during the five succeeding days, especially in the proximal convoluted tubules. After one week, mitoses decrease as the kidney undergoes progressive atrophy through dilatation of the pelvis. In the opposite kidney, mitoses in the tubules increase on the

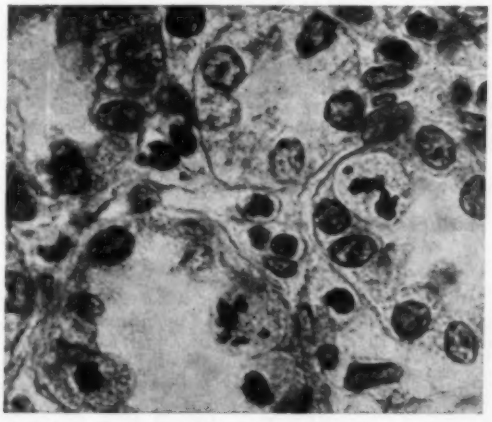


Fig. 1. Stathmocineses in convoluted tubules six days after renal obstruction

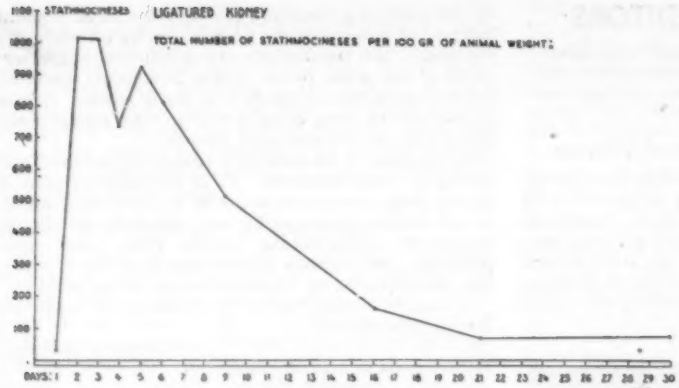


Fig. 2

second day after ligation, and reach a maximum at four days. The number of these mitoses remains at about the same level for as much as thirty days, the level being similar to that observed by the same method in compensatory hypertrophy.

These results are, in our opinion[3], comparable with those of Hartman[4], and Bollman and Mann[5]. These authors created uretero-intestinal fistulæ, leading to a slow reabsorption of urine in the intestine. They observed hypertrophy of the kidneys and also an acceleration of compensatory hypertrophy, with numerous mitoses in the tubules. Wilson[6] supposed that the hypertrophy of the kidneys may be induced by some urinary components. In hydronephrosis, their reabsorption by the kidney tubules would first promote mitoses in the ligated kidney. Soon after, these same substances, taken back by the general circulation, would stimulate cellular proliferation in the opposite kidney.

These experiments may be expected to throw more light not only on the mechanism of compensatory hypertrophy, but also on the chemical nature of the stimulus. Detailed results will be published shortly in the *Bulletin de l'Académie Royale de Médecine de Belgique*.

MARC HERLANT

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June 30.

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Induced Adenocarcinoma of the Stomach in Mice

THE great rarity of malignant tumours in the glandular stomach of all lower animals is generally admitted. The only records of spontaneous adenocarcinoma in mice seem to be three cases among 142,000 post-mortem examinations by Wells, Slye and Holmes[1], two in *Mus musculus* and one in *Peromyscus*. Strong[2] has reported adenocarcinoma in mice of his *NHO* line, derived from ancestors injected with methylcholanthrene and selected for resistance to local sarcoma-induction; but these animals are not representative of the species.

Two series of mice fed by us with cotton-seed oil previously heated to 350° C. for four hours have yielded tumours of the stomach unlike any that we have seen in other mice of similar age, in a variety of experiments during the past twenty years.

In the first series, forty-eight mice of mixed stock bred in this laboratory were fed on rat-cake[3], and drank daily a solution of heated cotton-seed oil (40 ml.) plus croton oil (4 ml.) dissolved in ether soap solution (356 ml.)[4], diluted with ten volumes of water. During the first year of experiment the ether was evaporated; but afterwards this was not done, as it was thought that the ether might improve the miscibility of the oil with the gastric contents. This solution contained 1·0 per cent of heated cotton-seed oil and 0·1 per cent croton oil, later reduced to 0·05 per cent because some animals died with hæmorrhages from the *pars glandularis* of the stomach. The average daily consumption per mouse was 5 ml.

Of nine mice that survived for eighteen months, two developed papillomas of the fore-stomach and one died with a massive malignant tumour involving both parts of the stomach. This tumour showed evidence of multiple points of origin and included squamous papilloma and carcinoma in the fore-stomach and adenoacanthoma in the glandular stomach. There was a secondary deposit of the latter type of tumour in a mesenteric lymph node. The last survivor of this group died after twenty-nine months of experiment, with four papillomas in the fore-stomach but no lesion of the glandular stomach.

In repetitions of this experiment, only tumours of the fore-stomach have so far occurred.

These experiments are summarized in the accompanying table.

In the second series of experiments, mice of similar origin were fed on powdered rat-cake containing 0·5 per cent by weight of black pepper. The drinking water contained 1·0 per cent heated cotton-seed oil in soap solution as previously described. Of five

Diet	Initial No. of mice	Stomach tumour incidence in survivors after first tumour	Duration of expt. at time of first tumour (days)	Diagnosis
Heated cotton-seed oil plus croton oil	48	3/9	540	Single squamous papilloma; 1 mixed squamous papilloma, squamous carcinoma and adenoacanthoma; 4 squamous papillomas
	12	1/3	387	1 big papilloma
	12	1/9	406	1 small papilloma
	12	1/5	452	1 medium papilloma
Croton oil only	12	1/6	487	1 small papilloma
Unheated cotton-seed oil only	12	1/11	310	Polyposis of pyloric canal
Cotton-seed oil plus croton oil	12	1/2	501	Polyp in duodenum close to pylorus

survivors for sixteen months, one died at that time with a large ulcerated tumour involving the pylorus and proximal part of the duodenum. This proved to be an adenocarcinoma, which had invaded the pancreas and a lymph node by direct extension. The other four survivors are still living after twenty-four months of experiment.

In another experiment, twelve mice on similar diet yielded no tumours in two that survived for more than fifteen months. In 309 mice of similar origin in other experiments not involving known carcinogens, no gastric tumours were found.

We have not been able to identify any known carcinogen in any of the heated fats or lipids, examined by methods that will detect one part in ten million of 3 : 4-benzpyrene. Moreover, even the presence of traces of known carcinogens would not account for the induction of adenocarcinoma of the stomach, since very large numbers of mice have been painted with potent carcinogens in many laboratories and must have licked off and swallowed considerable amounts without a single case of gastric adenocarcinoma being recorded. In this laboratory, mice fed with known carcinogens have frequently developed papilloma and carcinoma of the fore-stomach, but no tumours of the glandular stomach have occurred.

Evidence that heated fats and lipids contain potential carcinogens was recently reviewed by one of us[5]; but the induction of stomach tumours in mice in feeding experiments with such substances are few and not generally accepted. Waterman[6] claimed one case of adenocarcinoma of the stomach in a mouse fed with heated cholesterol oleate; but this has not been confirmed. Roffo[7] made numerous claims to have induced adenocarcinoma of the stomachs of rats fed on a variety of heated fats; but his copious illustrations do not support this diagnosis, and the work has not been confirmed. The two cases reported here cannot be statistically assessed; but it seems more probable that they were the result of the experiment than of chance.

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June 21.

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Physical Nature of Mouse Brain

Most histologists refer to the possible existence of a ground substance in the brain. Neurofibrils or glial fibres of the cortex impregnated in a successful silver preparation by no means completely fill the space available. Presumably in life these nerve terminals and glial fibres are even further separated from one another, since the processes of fixation, dehydration, etc., produce considerable shrinkage.

The physical properties of mouse brain as a whole, or of a piece of excised cortex, suggest that this is a substance with a continuous structure resembling that of a firm paste. It is opaque, soft, sticky, almost plastic, with a marked avidity for water.

Using either direct or dark-ground illumination, a film of fresh brain tissue appears granular, the separate granules adhering to one another and giving the whole field a hazy appearance. This granularity is evident at a magnification of × 80 and is best studied by means of dark-ground illumination at × 1,000 [1]. Even at this magnification separate granules are not distinct. Some show Brownian movement; but the majority adhere to one another, forming a more or less continuous film. Pressure on the coverslip causes sluggish streaming movements; but on releasing the pressure the displaced parts recoil and the original appearance is restored. A piece of fresh cortex was placed in 1 per cent aqueous methylene blue for one minute, crushed between two slides and examined by direct illumination. Movement between the two slides or light pressure caused streaming displacements of the blue cortical cells in an unstained granular matrix. On cessation of movement or release of pressure the original grouping of cells was restored. The cells themselves showed marked elasticity and could not be ruptured. They were intact, suggesting that the granularity was not due to cell debris. Heavier pressure merely thinned the film by causing a gliding movement of brain substance towards the edge of the preparation with extrusion beneath the borders of the covering slide.

It has been pointed out that the cells and fibrils impregnated with silver do not occupy all the available space in a histological preparation. It seems improbable that the granularity described merely represents the fresh state of those structures which become impregnated with silver in fixed tissue. A strong impression is received that this granular substance is the ground substance of the brain, being present in considerable quantity in the mouse cortex.

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[1] Taft, A. E., and Ludlum, S. DeW., *J. Nerv. and Ment. Dis.*, **70**, 360 (1929).

Some Unusual Findings on the Carcinogenic Action of Urethane in Mice

The induction of pulmonary tumours in mice following ethyl carbamate (urethane) treatment was originally described by Nettleship, Henshaw and Meyer[1] and has been confirmed by numerous workers. Similar effects of urethane in the rat have been noted by Jaffe[2]. The lung tumours described have been adenomata, usually multiple, appearing by three months after oral or injected, single or multiple doses of urethane (solutions of 5 or 10 per cent). In histological appearance the tumours are the same as spontaneous lung tumours arising in strain *A* mice and are of relatively low-grade malignancy. Successful transplantation has not been reported. The findings reported below were obtained on Rockland 'Swiss' albino mice in experiments investigating the carcinogenic action of urethane. The preliminary results obtained are so unusual that they are presented in a very incomplete form, so that the effects may be looked for by other investigators and the apparent action considered by those using urethane for clinical therapy. More detailed results will be presented shortly from a repetition of these and other experiments now in progress.

(1) Seven young female mice, 20 gm., received a single subcutaneous injection of 25 per cent urethane in a 5 per cent solution of zinc acetate, 0·1 c.c. per 10 gm. body weight, with the view of slow absorption. Such an injection caused a local tissue necrosis which healed in two to three weeks. After three months and four months respectively, in two mice a rapid general enlargement of lymph glands was noted. Both animals, at autopsy three weeks later, showed extensive lymphosarcoma, all glands being involved and markedly enlarged. Histologically the tumours were highly malignant, and extensive spread to gut, liver and kidneys was noted. The usual lung adenomata were also present. A third mouse after five months developed a slower growing tumour behind the humerus (at least one inch from the injection site). At autopsy a large, spongy, blood-filled tumour was found. Histologically the sections showed a malignant hæmangio-endothelioma, and no metastases were noted. Lung adenomata were present. Spontaneous malignant tumours of these types have never been observed in more than a hundred mice of the same strain and age used for other experiments in the laboratory. Control experiments using 25 per cent urethane and 5 per cent zinc acetate alone, and other substances causing retardation of absorption[3], are not yet complete.

(2) The lungs of a mouse containing multiple large adenomata induced by previous urethane treatment (discontinued for the previous five months) were ground in saline and injected into sixteen mice. One half of the group received intrapleural, and the other half subcutaneous, injections. After six months, four of each group were killed. Two mice of the first group and all four mice of the second group showed single or multiple lung adenomata. These tumours were typical of those induced by urethane injections.

(3) The lungs of mice which had received a single subcutaneous injection of 0·1 c.c. per 10 gm. bodyweight of 5 per cent urethane 3, 6, or 24 hours previously were ground up and injected into normal female mice. The equivalent of one lung was given to each animal by subcutaneous injection. Four animals of each of these three groups were killed five to six months later. Eleven of the twelve animals showed single or multiple lung adenomata similar in all respects to those caused by urethane injections. No other lesions were noted.

(4) Experiments using lung suspensions similar to those of paragraph (3), but made from animals which had received three daily injections of urethane, showed the same result, three of four mice developing lung adenomata.

(5) One control experiment was performed in which lungs from normal uninjected mice were administered in the same fashion under the same conditions. At autopsy, three mice which had received the injections did not show any lung adenomata.

It is obviously inadvisable to speculate on the significance of these preliminary experiments until more extensive ones have been completed. It appears, however, that rapidly growing, highly malignant tumours have been produced in mice following the injections of a strong urethane solution and zinc acetate. In other experiments a suspension of the lungs of mice which had received small doses of urethane, when given subcutaneously, produced adenomata of the lungs in a high percentage of animals. Although it is possible that the injected urethane might be concentrated in the lung tissue, there was no experimental evidence to suggest this as the explanation of these observations.

This work has been carried out with grants in aid from the National Cancer Institute of Canada and the Ontario Cancer Research Foundation.

R. L. Noble
M. Jean Millar

Collip Medical Research Laboratory,
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London, Ontario.
June 30.

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Reaction of Effector Cells to Chemical Transmitters

Earlier work has led us to the view that the intervention of peripheral elements has a fundamental role in the regulation of nervous activity[1]. This regulation, in fact, is not exclusively conditioned by the nature of the transmitter or by its mode of formation. It depends to a great extent on the more or less specific reactions of the effector cells to the substances liberated by nerve stimulation. Thus two transmitters, acetylcholine and adrenalin, act in a different way on organs like the heart and the intestines, which present different histological structures. But adrenalin causes contraction of the uterus of the pregnant cat and relaxation of the uterus of the non-pregnant cat, that is, the action of the same transmitter is dependent on the functional conditions of the reacting tissue. This suggests the possibility of local intervention of sex hormones in the peripheral regulation mechanisms of the uterus; for it has been shown by Courrier that these hormones are capable of direct action on that organ and that the hormonal antagonism between œstrin and progesterone, for example, is directly concerned with its effector cells.

We have therefore carried out more general experiments on the isolated uterus of the rabbit, which was the test-organ of Courrier, to find out to what extent the responses of this organ to acetylcholine and adrenalin may be influenced by previous treatment with different sex hormones.

The rabbit uterus reacts to acetylcholine as well as to adrenalin by contraction. This analogous action is remarkable; for the effects of both are not only inhibited by atropine, but also sensitized by eserine. The actions of the two transmitters can, however, be differentiated by yohimbine, which reduces the effect of adrenalin without modifying that of acetylcholine; and we observed also that relatively small doses of adrenalin could produce contractions in uteri which showed very slight sensitivity to acetylcholine. It thus appears scarcely likely that adrenalin produces its contracting effect by mobilizing acetylcholine in that organ.

This curious synergism of the two transmitters is not affected by sex hormones. The untreated uterus of very young animals is absolutely insensitive to the two substances, and becomes sensitive to both after 30–50 γ of œstrin have been administered to the animals over a period of several days. The same modifications occur with the uteri of ovariectomized

rabbits. This evolution of sensitivity: (1) does not increase with the administration of larger amounts of the hormone than the active dose; (2) is not peculiar to œstrin, but can also be obtained with testosterone (1–10 mgm.), progesterone (1–10 mgm.), desoxycorticosterone (1–10 mgm.), or with a mixture of œstrin and progesterone initiating the classical transformation of the uterus mucosa described as 'dentelle'. The reaction of the uterus to the transmitters seems, however, more marked after the administration of testosterone or œstrin than after that of desoxycorticosterone.

But this apparent uniformity of response hides very complex cell changes. When the rabbit uterus is immersed in Tyrode solution for 15–90 min. in the presence of oxygen and at a temperature of about 37°, it gives off a substance which is capable of decreasing the muscular tone of an isolated intestine preparation. This tone can be increased by the fluid obtained in the same circumstances from the uterus of an animal which has been treated with testosterone. The latter effect may also be observed, though generally to a lesser extent, with fluids obtained from rabbit uteri treated with progesterone alone or combined with œstrin. The liquid obtained after desoxycorticosterone sometimes provokes an amplification of the spontaneous intestinal movements. We conclude from these results that sex hormones are capable of creating modifications in the biochemical reactivity of the receptor cells of the uterus which may result in the secretion of substances capable of influencing in a more general way the tone of unstriated muscles, and of acting by this indirect mechanism on the humoral agents of the autonomic nervous system.

These results, however, do not explain why the same transmitter, adrenalin, causes the uterus of the rabbit to contract and the uterus of the guinea pig to relax, that is, of animals of the same species presenting analogous hormonal levels. We therefore administered a small dose of adrenalin to the isolated rabbit uterus and transferred, after contact varying from 15 to 40 min., the surrounding fluid to an isolated guinea pig uterus. This fluid produced a contraction of the guinea pig uterus which originally reacted to the administration of adrenalin with relaxation. The effect is not reciprocal in character; fluid obtained after the action of adrenalin on the guinea pig uterus still has a contracting effect on a rabbit uterus. On the other hand, when the fluid containing adrenalin after having been in contact with the rabbit uterus is transferred to the isolated intestine, it causes the usual inhibitory action of adrenalin on that organ, and a fluid containing adrenalin after having been in contact with the small intestine continues to produce contraction of the isolated rabbit uterus.

These findings suggest the presence of a special agent in the rabbit uterus conditioning the paradoxical action of adrenalin on that organ. They suggest in a more general way that the biological analysis of isotonic liquids which have been in contact during various periods and under various conditions with isolated organs may constitute a profitable method for the study of the behaviour of effector cells.

B. Minz

Laboratoire de Physiologie générale de la Sorbonne, Paris.

April 20.

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A Nemestrinid Parasite of *Schistocerca gregaria* (Forsk.)

During dissections of an immature male specimen of the desert locust, *Schistocerca gregaria* (Forskål), a yellowish larva of Nemestrinidæ was found feeding on the testes and the surrounding adipose tissue. It was 1 cm. long. Its posterior end was surrounded by a chitinous cup leading to a slender respiratory tube *c.* 2 cm. long, which was constricted transversally along its whole length (these constrictions disappear when pressed during the preparation). The respiratory tube went longitudinally along the midgut and then was bent at right-angles towards the spiracle of the first abdominal segment. The tube was more or less uniform in width, becoming dilated at the cup surrounding the posterior spiracle of the larva. The end of the tube entered the meeting place of the tracheæ, which was considerably expanded. The chitin of this end was blackish-brown, due to pathological changes.

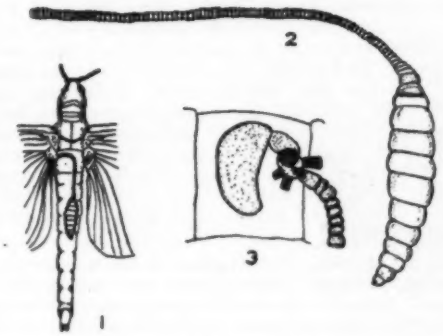

Fig. 1. *Schistocerca* dissected showing the Nemestrinid larva with the respiratory tube. ½ Nat. size
Fig. 2. Nemestrinid larva with the respiratory tube. × 3
Fig. 3. The spiracle, tympanal organ and the respiratory tube shown from inside

Potgieter[1] has described a Nemestrinid *Simmictus costatus* (Lw.) developing inside the body of *Locustana pardalina* (Wlk.) in South Africa. Noble[2] described larvæ, pupa and adult of *Trichopsidea astracea* (Westw.) from *Chortoicetes terminifera* (Wlk.) in Australia. Fuller[3] has given a full description of *Trichopsidea astracea* (Westw.) on various grasshoppers there. Crouzel and Salavin[4] described in detail two species of *Neorhynchocephalus*, *N. sulphurous* (Wied.) and *N. vitripennis* (Wied.) parasitizing the Acrididæ *Trigonophymus arrogans* Stal. and *T. elongatus* Giglio-Tos.

Unfortunately, our larva remained unidentified, as the attempt to transfer it into the body of another grasshopper failed. According to Dr. B. P. Uvarov (in correspondence), this is the first record of a Nemestrinid parasite of *Schistocerca gregaria*. I wish to express my thanks to Dr. Uvarov for his help and criticism in the preparation of this note.

A. Shulov

Hebrew University, Jerusalem.

Feb. 3.

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Antiquity of Man in Australia

For nearly eighty years, one of the most prominent items of anatomical evidence in support of the antiquity of man in Australia has been a fragment of a supposed human molar, found by Krefft in the Wellington Caves of New South Wales.

Early doubts expressed as to the value of its evidence were based on the possibility of its adventitious presence in the caves. These doubts were afterwards dispelled by eye-witnesses, and it is now accepted that the tooth, when found, was imbedded in the characteristic cave breccia, together with remains of *Diprotodon* and *Thylacoleo*. According to the estimate of Sir Edgworth David in 1923, the association dates back to a period 7,000–12,000 years ago.

The fossil has been discussed by Krefft (1870–74), Etheridge (1890–1916), David (1923) and Anderson (1933), all of whom have accepted its human origin.

Recently, the human origin of the fragment has been questioned by Dr. T. D. Campbell, and I have considered *de novo* its possible relation to the lower mammals. To this end, the morphology of the fragment and the type and sequence of the attrition which have produced its crown pattern have been minutely compared with all indigenous Australian mammals, with all introduced and domestic mammals, and with many exotic species as well, which could possibly yield a dental fragment of the size of the fossil. Three chief results have accrued from this examination.

(1) The fossil is derived from a tooth possessing extreme functional brachydonty. At the same time, the occlusal surface exhibits large exposures of dentine in juxtaposition with broad enamel structures. While both features may be separately found in the molars of a few mammals, their concurrence in the same species is generally precluded by the structural ground-plan of the tooth. Consideration of this fundamental peculiarity of the fossil early led me to abandon the view that it was a molar tooth at all.

(2) On transferring attention to premolar teeth, close analogies in structure were soon found to exist between the fossil and the third and fourth premolars of the Macropodinæ, in an advanced stage of wear. In particular, the highly characteristic pattern of the occlusal surface of the fossil is very closely reproduced in the premolars of the black-tailed wallaby (*Macropus walabatus* L. and G.), and a study of the successive stages of attrition through which such teeth have passed correlates in the clearest way all the main structures of the fossil, with their originating centres in the unworn premolar.

(3) After direct comparison with relevant material, and with the above general conclusions as a guide, I have no doubt that Krefft's find was derived from the posterior half of the upper fourth premolar or seccator, of the right side, of *Macropus* (*Protemnodon*) *anak*, Owen, a giant Pleistocene 'wallaby', remains of which are already known from the caves, and which occur also in profusion in beds of similar and earlier age over a wide area of eastern and south-eastern Australia.

A detailed, illustrated account will follow.

H. H. Finlayson

South Australian Museum.
March 30.

Origin of the Golden Hamster *Cricetus auratus* as a Laboratory Animal

The golden (Syrian) hamster *Cricetus auratus* is now being bred in scientific institutions in Europe and America and has proved useful for various experimental investigations. Workers from different countries have written to me inquiring about the origin of the golden hamster, which is now widely distributed in many laboratories. Some of the correspondents are interested in using *Cricetus auratus* for genetics, others in the history of this hamster as a laboratory animal.

In 1930 the late Prof. Aharoni, of the Department of Zoology of the Hebrew University, Jerusalem, went on a zoological expedition to Syria (he was particularly interested in the fauna of Antioch). We were engaged on investigations for the Royal Society on Mediterranean kala azar, and the only suitable experimental animal then known was the Chinese hamster, which had to be imported from the Far East and had the additional disadvantage of not breeding in captivity. Stocks could only be replenished by importing, and lengthy experiments in the Middle East were imperilled by epidemics of *Pasteurella* to which this animal is very susceptible.

Prof. Aharoni undertook to bring specimens of *Cricetulus phœus* for our work. In addition to specimens of *Cricetulus phœus* (which were also unsatisfactory because they did not breed in captivity), Prof. Aharoni brought back a litter of eight golden hamsters collected near Aleppo which he reared and presented to the Department of Parasitology in July 1930.

Four of the animals escaped, one female was killed by a male and only three animals—one male and two females (all litter mates)—remained. From these three animals Mr. H. Ben Menahem succeeded in raising litters, and it was quickly established that this species breeds readily in captivity. It was first used for investigations on kala azar in November 1930, and was afterwards found valuable for work on tuberculosis and brucellosis. As soon as this was realized, I decided to distribute the animal as widely as possible and avoid the risk of maintaining a valuable species in one laboratory. (The animal is very susceptible to *S. typhimurium*, and wherever there is a danger of contamination with this *Salmonella*, it is advisable to vaccinate.) I brought specimens to the Collège de France (Prof. Nattan Larrier), to the Medical Research Council and to the Wellcome Bureau of Scientific Research, where Dr. E. Hindle succeeded in breeding them. Shortly before the Second World War I sent animals to India for kala azar research, and the late Prof. I. J. Kligler sent a batch to America. I also sent several batches recently to Egypt. During the War, animals infected with kala azar were sent to the United States at the request of the American Army authorities for experiments on chemotherapy; but these animals were probably not used for breeding.

To the best of my knowledge all the golden hamsters now in use as laboratory animals in Europe and America originate from the above-mentioned three litter mates—one male and two females brought to the Department of Parasitology of the Hebrew University of Jerusalem in July 1930.

It would be interesting to collect more wild specimens from the neighbourhood of Aleppo, and I

hope that some worker favourably situated for this purpose will succeed in doing so.

S. Adler

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Determination of Plant Densities

In surveying plant associations, it is usual to determine the valence by noting the presence or absence of each species in sample areas, and the density by counting the number of individuals of each species in the same, or other, sample areas. Two difficulties are frequently encountered in determining densities by this method, the length of time needed in the field and the intermingling of root systems of individual plants of the same species with consequent indecision as to the exact number present in the sample. The following method has the advantage of requiring one set of observations only, from which valence and density may be determined, and of avoiding counts within the sample areas.

Suppose the species has a density N/A plants per unit area and that a sampling area a is taken t times at random. Then the expected number of plants per trial will be aN/A, and the number y_0 of trials containing no individuals of the species would be expected to be given by the expression

$$y_0 = t \exp(-aN/A).$$

$$\text{Whence } \frac{N}{A} = \frac{1}{a} \cdot \log_e \cdot \frac{t}{y_0}.$$

If the number of trials is 50 and the sampling area 0·1 square metre, a graph relating density and y_0 can be drawn and shows a remarkable sensitivity for densities 33 per sq.m. to 3 per sq.m. By increasing the sampling area to 1 sq.m., the density values on the graph are reduced ten times, and we have a sensitive range from 3·3 per sq.m. to 0·3 per sq.m.

Much time has been saved in the field and results are reasonably in accord with densities found by the more laborious method.

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June 26.

Metabolism of α : β-Dihydroxy-γ-(2-methylphenoxy)propane ('Myanesin')

In a recent communication[1], Wyngaarden, Woods and Seevers have shown that 'Myanesin' administered intravenously to dogs appears in the urine mainly in combination with glycuronic acid, while a small amount is excreted without change. We have found that after intravenous administration to humans or rabbits, a portion is oxidized and excreted as α-hydroxy-β-(2-methylphenoxy)propionic acid. The acid may be isolated by acidifying the urine to *p*H 3, extracting with ether continuously for 24–48 hours, transferring from the ether extract into sodium bicarbonate solution and recovering from the aqueous solution by acidifying and extracting with ether. The ether-soluble product is crystallized first from carbon tetrachloride, then from water and finally from chloroform. The pure acid melts at 146–147° (corr.) (found: C, 61·2; H, 6·1; $C_{10}H_{12}O_4$ requires C, 61·2; H, 6·1 per cent). The acid is not optically active. It is identical with the acid obtained by condensing *o*-cresol with β-chlorolactic acid (found: C, 61·1; H, 6·1 per cent).

We are indebted to Dr. F. Barnett Mallinson for supplies of urine from patients who had received 'Myanesin'. Our thanks are also due to the directors of the British Drug Houses, Ltd., for permission to publish this note.

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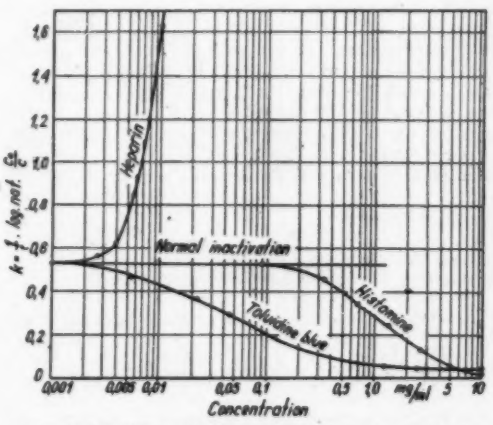
April 15.

[1] *Proc. Soc. Exp. Biol. and Med.*, **66**, 256 (1947).

Histamine – Heparin – Thrombin Chain Mechanism

Earlier experiments of ours have shown that the organism regulates the coagulability of the blood by the inactivation of thrombin[1,2]. Many factors take part in the system causing the thrombin to disappear. We distinguish an adsorption effect and a fermentative inactivation process, and indicate the inactivating process by its reaction velocity factor.

We have worked out a simple and rapid process for investigating the inactivation[3]. We put thrombin of a known activity into the serum under investigation, and after an incubation period of 1, 2, 3, 5 or 10 min., we determine the time in which samples taken from the mixture make the fibrinogen coagulate. As a result of the inactivation we get increasingly longer clotting-times. From the clotting-times we determine their thrombin activity on the basis of an empirical relation, and from the data thus obtained we calculate the reaction velocity factor ($k = 1/t$ log. nat. co/c).



Change in thrombin inactivation reaction-velocity constant under the effect of heparin, toluidine blue and histamine respectively, in rabbit serum

Heparin increases the reaction velocity of the inactivation (see graph). If we bind the heparin with toluidine blue, the velocity of the inactivation diminishes decidedly[4]. We find that histamine, both *in vitro* and *in vivo*, likewise strongly decreases the

inactivation, and thereby shifts the clotting capacity of the blood towards coagulation[5]. We have also shown that histamine and heparin bind one another, and have obtained a colour reaction from this[6].

As histamine and heparin are both constantly present in the blood in physiological circumstances, it must be supposed that the normal coagulability of the blood is regulated intravasally by histamine – heparin equilibrium. If this equilibrium shifts towards histamine there is a diminished inactivation and the blood coagulates better, which in certain cases can lead to intravasal fibrin precipitation. But if there is a preponderance of heparin the effect of the inactivating system increases and the blood does not clot so well. These phenomena have been thoroughly observed in pathological[7,8] and experimental[3,9,10] conditions.

Jancsó demonstrated in 1931 that a preliminary condition for the accumulation process of reticulo-endothelial systems was that the colloids to be eliminated from the blood are enclosed in a covering of fibrin, and that this colloid-fibrin complex becomes attached to the endothelium[11]. It was later also found that this occurs also as an effect of histamine[12]; but intermediate links in the chain were lacking to explain how, as an effect of histamine, the fibrin appears in the blood.

But on the basis of the foregoing, the route of the chain mechanism would appear to be briefly that histamine is produced as an effect of the foreign substances introduced into the blood. This binds the heparin and thus inhibits the inactivation of thrombin. This in turn leads to the formation of thrombin and causes intravasal fibrin precipitation. The precipitating fibrin carries off the colloids, which attach themselves to the walls of the endothelium, where their phagocytosis begins. When this phenomenon has taken place, the increasing liberation of heparin compensates for the increased clotting capacity of the blood.

On this basis, the physiological sphere of thrombin must be extended. The function of thrombin is not only to bring about extravasal clotting, but also to fulfil an at least equally important task intravasally, in starting the accumulation in the reticulo-endothelial system as one of the links in the chain of the whole process. This also throws a new light on the problem of thrombosis. Thrombosis occurs when the organism cannot, by increased liberation of heparin, restore to normal the lowered thrombin inactivation required for colloid accumulation.

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[1] Gerendás, M., *Nature*, **157**, 837 (1946); *Hung. Acta Physiol.*, **1**, 97 (1948).
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[3] Gerendás, M., *Schweiz. med. Wschr.* (in the press).
[4] Gerendás, M., Udvardy, M. D. F., Pálos, A. L., and Csefkó, I., *Acta Physiol. Scand.* (in the press).
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[6] Gerendás, M., Csefkó, I., and Udvardy, M. D. F., *Acta Physiol. Scand.* (in the press).
[7] Pálos, A. L., *Schweiz. med. Wschr.*, **78**, 112 (1948).
[8] Pálos, A. L., *Schweiz. med. Wschr.* (in the press).
[9] Csefkó, I., Gerendás, M., and Udvardy, M. D. F., *Arch. Biol. Hung.* (in the press).
[10] Csefkó, I., Udvardy, M. D. F., and Gerendás, M., *Arch. Biol. Hung.* (in the press).
[11] Jancsó, M., *Klin. Wschr.*, **10**, 537 (1931).
[12] Jancsó, M., *Nature*, **158**, 227 (1947).

Hæmoglobin – Methæmoglobin Mixtures

We[1] have recently had an opportunity of confirming, in a case of familial methæmoglobinæmia, the shift to the left in the oxygen dissociation curve of hæmoglobin which Darling and Roughton[2] found in hæmoglobin – methæmoglobin mixtures. They suggest that the shift in the curve may be explained by the existence of intermediate compounds, the affinity of which for oxygen is greater than that of hæmoglobin. On this assumption, the formation of methæmoglobin from hæmoglobin does not take place in a single step; but the four iron atoms of the hæmoglobin molecule may be oxidized separately and successively. If the iron in the hæmoglobin (or oxyhæmoglobin) molecule is represented as $(Fe^{++})_4$, the iron in the intermediate mixed molecules would be $(Fe^{+++})(Fe^{++})_3$, $(Fe^{+++})_2(Fe^{++})_2$, $(Fe^{+++})_3(Fe^{++})$, and that in methæmoglobin itself $(Fe^{+++})_4$. As the shift in the dissociation curve is fairly large, it is evident that quite appreciable amounts of the intermediate compounds would be present in methæmoglobin – hæmoglobin mixtures, and might afford spectroscopic evidence of their presence. Apart from its theoretical interest, the question is of some practical importance, for alterations in the absorption spectrum due to this cause would necessitate modifications in the estimation of blood methæmoglobin made by optical methods, for example, that of Evelyn and Malloy[3].

We have looked for spectroscopic evidence for the presence of the intermediate compounds by making differential measurements of the absorption at the red end of the spectrum (where methæmoglobin shows a strong absorption band), comparing optical and physical mixtures of hæmoglobin and methæmoglobin in a Spekker absorptiometer. Using two pairs of closely matched 1-cm. cells, we first filled one member of each pair with a definite volume of methæmoglobin solution containing 1 gm./100 ml. pigment. (The solution was prepared from toluene-laked, washed ox erythrocytes by the action of a small excess of sodium nitrite. It was filtered and exhaustively dialysed at 4° in a rocking dialyser and diluted with *p*H 7·4 phosphate buffer.) The other cells were filled with the same volumes of a separately dialysed, filtered and buffered solution containing 1 gm./100 ml. oxyhæmoglobin. Each oxyhæmoglobin-containing cell was then examined in conjunction with a methæmoglobin cell.

The difference in optical density between the pairs of cells (using 2 mm. Hilger red No. 1 and 2 mm. Calorex filters) was 0·002, representing the difference between the pairs of glass cells. On mixing the contents of one pair of cells, to give a 50 per cent mixture of oxyhæmoglobin and methæmoglobin, the change in absorption was not greater than 0·001, nor was any further change found in readings taken up to 18 hr. after mixing. The total absorption under the conditions used was 0·805, so that the change on mixing was less than 1 in 500 of the total absorption, that is, well within experimental error. Examination of the solutions (diluted 1 in 5) with the Hartridge reversion spectroscope also failed to show any difference between the optical and physical mixtures in the position of the methæmoglobin band in the red part of the spectrum.

If the explanation of Darling and Roughton for the shift in the dissociation curve is correct, it would appear, therefore, that the absorption spectrum of hæmoglobin derivatives is determined not by the

molecule as a whole, but by the sub-molecules containing one iron atom.

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April 20.

[1] Gibson, Q. H., and Harrison, D. C., *Lancet*, ii, 941 (1947).
[2] Darling, R. C., and Roughton, F. J. W., *Amer. J. Physiol.*, **137**, 56 (1942).
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Crystal Structure of Nitronium Perchlorate

We have made an X-ray examination of the nitronium perchlorate of Goddard, Hughes and Ingold[1] and find, in agreement with Millen's observations on its Raman spectrum[1], that the crystal structure contains the ions NO_2^+ and ClO_4^-.

The crystals are monoclinic, the unit cell having dimensions $a = 9{\cdot}25$ A., $b = 6{\cdot}99$ A., $c = 7{\cdot}34$ A., with $\beta = 113{\cdot}5°$, and containing four molecules of $NClO_4$. The existence and general arrangement of the ions was discovered from two-dimensional Patterson syntheses of the intensities of X-ray reflexions in the three principal zones, and confirmed by comparison of observed and calculated structure amplitudes; the chlorate and nitronium ions are arranged alternately along twofold axes, in accordance with the space group $C\ 2/c$, the nitrogen and chlorine atoms lying on the twofold axes, with all the oxygens in general positions. By using $\{hkl\}$ structure amplitudes in sectional projections[2] we find that the NO_2^+ ion is linear with N—O $\sim$ 1·1 A., and the ClO_4^- ion approximately tetrahedral, with Cl—O $\sim$ 1·5 A. Successive Fourier refinement is now being applied to obtain more accurate values of these bond-lengths.

We are indebted to Prof. C. K. Ingold and Mr. D. R. Goddard for providing crystals specially prepared for this work.

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April 23.

[1] *Nature*, **158**, 480 (1946).
[2] Booth, *Trans. Farad. Soc.*, **41**, 434 (1945).

Emissivity of Small Particles in Flames

It is a striking fact that solid (or massive) carbon behaves as a black body, whereas small carbon particles which are responsible for the luminosity of hydrocarbon flames have an absorption coefficient which is strongly dependent on wave-length. This difference is important in the measurement of the colour temperature of luminous flames. It has been shown theoretically by Mie[1] that the absorption coefficient is strongly dependent on wave-length when particles are smaller than a wave-length, an effect which is analogous though not identical with the dependency of scattered light on wave-length.

We have made some optical measurements on a stationary flame of aluminium flakes in air. These experiments differed from the often repeated measurements on photo-flashes since the flame had a greater depth (5–10 cm. diameter). The intensity distribution in the flame was unusual. The radiation consisted of weak AlO bands and a strong continuum which extended from the red far into the ultra-violet regions. The colour temperature was about 3,600° C. It may be shown theoretically that the enthalpy of the exhaust gases permits the temperature of the flame to reach the boiling point of aluminium oxide (Al_2O_3), which is 2,980° $\pm$ 60° C., and that nearly all the oxide is vaporized. When we threw an image of the anode of the carbon arc on to the aluminium–air flame, we observed very weak absorption in the visible and increasing absorption towards the violet region. At 3100 A. all light from the arc was absorbed. The emission coefficient, therefore, became very nearly equal to unity in the ultra-violet. By comparing the brightness of the flame at 3100 A. with the brightness of the carbon arc anode, we estimated a brightness temperature which was a little below the calculated (theoretical) temperature. Line reversal measurements (ordinarily a little high on account of the scattering effect) gave a slightly greater value than the calculated temperature.

The close agreement of these results satisfied us that the temperature of the flame was actually the boiling point of aluminium oxide. If we adopt this value, however, an explanation is needed for the high colour-temperature observed, or in other words, for the strong dependency of emissivity on wave-length. We believe that most of the aluminium oxide formed in the flame is initially in the gaseous state. The radiation may therefore originate from gaseous aluminium oxide or other gaseous products (excited thermally or by chemiluminescence), but no continuum of gaseous origin is known which extends so far. Moreover, it is perhaps significant that the conditions are very similar to those in the luminous hydrocarbon flame, where emission is undoubtedly due to small particles.

We suggest, therefore, that small droplets of aluminium oxide are the emitters in the aluminium flame, and that these particles are formed by condensation in the flame. Produced in this way, the particles are finely dispersed and very small. Their temperature is identical with the gas temperature, even if catalytic reactions occur on the surface, because the heat transfer numbers of such particles are extremely high. Some of these particles are no doubt smaller than the wave-length of light (Shechter *et al.*[2] have produced evidence of this), and the absorption and emission characteristics of such particles will behave in the same way as radiant soot. The abnormally high colour-temperature is again attributed to the optical properties of very small particles. Moreover, the colour temperature depends upon the thickness of the optical layer, because the thicker the layer the more the radiation will approach black-body conditions.

Magnesium behaved in a similar manner.

We are indebted to the Chief Scientist, Ministry of Supply, for permission to publish this communication.

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W. G. Parker

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South Farnborough, Hants.
April 12.

[1] Mie, *Ann. d. Phys.*, **25**, 377 (1908).
[2] Shechter, Roginsky and Sakharova, *Acta Physicochim. U.R.S.S.*, **21**, 3, 463 (1946).

Application of Measurements of Semi-conductivity to Heterogeneous Reactions

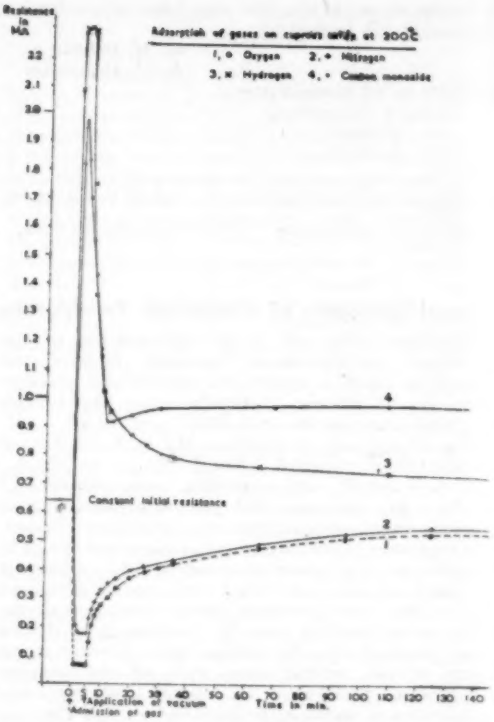
In the present investigation pure oxide films are obtained by the oxidation of evaporated metal films. Normal high-vacuum precautions are observed in the use of all-glass, greaseless systems with precise temperature control. The method of investigation which has been developed is based on the semi-conducting properties of these oxide films. Simultaneous pressure and resistivity measurements are made during the adsorption and desorption of various gases on the oxide films over a range of temperatures between 0° and 250° C. While variations in conductivity of bulk semi-conductors on exposure to air have been previously observed and reported (Anderson *et al.*), the effect has not previously been applied to the problem of catalysis. Preliminary investigations which have been carried out on copper oxide films have demonstrated the efficiency in obtaining reproducibility of the film during periodic oxidation and reduction.

On oxidation of the copper film during the initial period of oxidation the resistance measurements are effectively those of the residual copper layer, being of the order of one ohm in typical cases. This period is characterized by a parabolic uptake of oxygen. At the end of this period, which occupies several hours at 200° C., there is an extremely rapid change in resistance over a period of a few minutes before stabilizing at a high value, 350 k.ohm in a representative case. After this there is a slow exponential change in resistance to a final value corresponding to that of pure cupric oxide obtained after approximately 25,000 min. at 200° C. In this final state the film shows no increase in resistance on sustained pumping at 10^{-7} mm. mercury pressure.

On hydrogen reduction there is an induction period after which the resistance increases to a very high maximum value, corresponding to the formation of cuprous oxide in the non-conducting state. Further reduction gives a rapid fall in resistance to a value of about 50 k.ohms in a typical case, at which point erratic readings are obtained, fluctuating between that value and a few hundred ohms. This continues for a period of about 15 min. and corresponds to the embrittlement phenomenon reported by Garner and Stone[1], probably due to the escape of water from the film. After this characteristic period the resistance falls exponentially until after about 30,000 min. the original resistance of the copper film is obtained.

For studying the effects of adsorbed gases, the films were employed in the semi-conducting region corresponding to a stoichiometric ratio lying between cuprous oxide and cupric oxide. When the film had been oxidized to the required composition it was subjected to prolonged pumping at 10^{-7} mm. mercury pressure, during which there was an increase in resistance to a constant value, 650 k.ohms in a typical case. The value of this maximum corresponds very closely to the final value of the pure cupric oxide film and did not vary significantly over a wide range of composition. This corresponds with the observations of Anderson and others on the effect of the evacuation of bulk semi-conductors.

Quantitative and qualitative information has been obtained concerning the effect of the adsorption of oxygen, nitrogen, hydrogen and carbon monoxide on the semi-conducting films in this condition. Admissions of oxygen at a series of temperatures and at pressures varying between 10^{-3} mm. and 0·3 mm.


Resistance in kΩ
Adsorption of gases on cuprous oxide at 200°C
1, ○ Oxygen 2, • Nitrogen
3, × Hydrogen 4, ◦ Carbon monoxide
Constant initial resistance
Application of vacuum
Admission of gas
Time in min.

mercury pressure have shown that there is an immediate fall in resistance of great magnitude taking place within the first five seconds, followed by a slightly slower change over a few minutes (curves 1 and 2). The films are only exposed to the oxygen for a few minutes and are then subject to hard vacuum, 10^{-7} mm. pressure being attained in approximately 15 sec. During evacuation there is an increase in resistance, a very rapid second-order change at first, but becoming exponential after about 30 min. The final value obtained after about 2,500 min. is, for temperatures above 200° C., identical with the initial value; but below this temperature very protracted pumping fails to re-establish the original equilibrium condition. All curves show a very high degree of reproducibility.

The effect of nitrogen is qualitatively the same as for oxygen, while helium, which has no effect alone, modifies the effect of both adsorption and desorption by slowing down both processes to a marked degree.

On the adsorption of carbon monoxide or hydrogen the resistance increases rapidly to a very high value (curves 3 and 4). In the case of hydrogen the process is reversible, but in the case of carbon monoxide the removal of the gas, possibly as carbon dioxide, is complicated by the apparent immediate reduction and sintering of the surface, which completely alters the film characteristics. After adsorption of carbon monoxide it is possible to return the film to its standard state only by oxidizing the film completely, reducing to copper and reoxidizing. Only after this drastic processing does the film reproduce earlier results. This effect has been reported by Garner and Stone on bulk copper oxide.

The investigation is being extended to a range of temperatures enabling temperature coefficients of

the various processes to be established, and to various other oxides. Precision measurements of gas adsorbed and desorbed are being introduced, and the significance of substrate is being investigated.

Although too early to embark on any rigid theoretical consideration of the significance of the results, it is clear that providing the general picture of semi-conduction as given by Mott is accepted, then these measurements must yield direct information of the nature of the catalytic processes occurring, as related to adsorbed gases on semiconducting oxide catalysts.

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April 20.

[1] Garner, W. E., and Stone, F. S., *Nature*, **158**, 915 (1946).

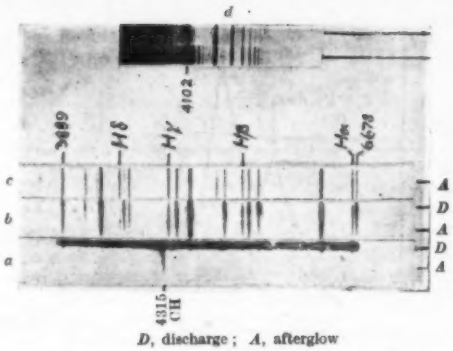
Afterglow of the Balmer Spectrum of Hydrogen

In a paper published during the War the late Lord Rayleigh reported some new experiments about the hydrogen spectrum, indicating a duration of Balmer lines of more than 10^{-6} sec., which is roughly one thousand times greater than the values calculated from quantum mechanics and experimental results with positive rays. The method consists in producing a strong luminosity induced by a powerful condenser discharge in an electrodeless glass tube. Each discharge produces a jet of luminosity, squirting out of the electric field by thermal expansion into a side tube where the decay of the Balmer lines is observed and measured[1].

Lord Rayleigh did not attempt any explanation of this result and apparent discrepancy. Jablonski has remarked that the mean duration of lines is not always identical with the mean life in initial states of corresponding transitions. After having considered the various mechanisms which can produce atoms in the upper level, he thinks that the persistence of the luminosity results from the radiative recombination of atomic hydrogen ions[2].

Born, Fürth and Ladenburg[3] prefer to believe that Lord Rayleigh's experiments can be understood on the basis of the known relatively long life of free hydrogen atoms and their re-excitation "by radiation and, especially, by the diffusing electrons and positive ions". The rise of the relative intensity of the blue-green $H\beta$ lines (4861 A.) observed by Lord Rayleigh with decreasing luminosity is ascribed to the sensitivity of the eye, which has a maximum in the green part of the spectrum.

In view of making a choice between the two above interpretations, new experiments were performed on the hydrogen afterglow. The experimental arrangement is the same as already described[4]. It permits a careful separation of the light of the discharge from that of the afterglow one. The excitation energy used in our experiments is weak and is not sufficient to show the persistence of the luminosity in pure hydrogen. But when this element is diluted in neon or helium a strong afterglow can be observed. In the case of helium, traces of hydrogen almost always present are sufficient to give the phenomenon. Other impurities like CO and CH destroy the afterglow: the spectrum *a* shows that only the band 4315 of CH persists in this case. The impurities are eliminated either by producing a powerful discharge between two magnesium electrodes or by immersing the discharge vessel in liquid nitrogen.



D, discharge; *A*, afterglow

Spectrum *b* shows the modification of the emission of helium containing traces of hydrogen when the discharge is cut off. The Balmer lines suffer less variations than He I lines, and the relative intensity of H I increases with time. This later variation can be seen easily by comparing the spectrum at the beginning of the afterglow with spectrum *c* emitted 10^{-3} sec. after breaking the discharge. The duration of the lines increases with the quantum number *n* and the intensity of distribution of the Balmer spectrum varies with time (compare spectra *b* and *c*).

By measuring the decay of luminosity with the time, we have evaluated the duration of the H_γ line at 10^{-4} sec. after breaking the discharge.

It is possible to show that the emission in question follows the capture of electrons by ions by studying the afterglow at the limit of the Balmer series. The discharge and the afterglow were photographed in the ultra-violet region with an Arnulf – Lyot spectrograph. The results are illustrated by the spectrum *d*. In the afterglow, the hydrogen spectrum is extended further than in the discharge; at the same time, the higher level lines of He I grow in intensity.

The above results, although they do not allow a direct comparison with Lord Rayleigh's experiments, show that hydrogen atoms can radiate the whole Balmer series in afterglow. The persistence of the lines at the limit of the series seems to be conclusively in favour of an emission by radiative recombination between ions and electrons.

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Louis Herman

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Faculté des Sciences,
Paris. April 14.

[1] Rayleigh, Lord, *Proc. Roy. Soc.*, A, **183**, 26 (1944).
[2] Jablonski, A., *Nature*, **155**, 397 (1945).
[3] Born, M., Fürth, R., and Ladenburg, R., *Nature*, **157**, 159 (1946).
[4] Herman, L., *C.R. Acad. Sci. Paris*, **225**, 112 (1947).

Decay Scheme of ^{181}Hf

In continuation of our previous analysis of the decay scheme of ^{181}Hf [1], we have carried the work further with higher resolving power and using a spectrometer with a thin Geiger–Müller window. We have also carried out delayed coincidence measurements to study the metastable state reported by De Benedetti and McGowan[2]. We have attempted to eliminate various possible decay schemes which have been proposed[1-3], in favour of one to be discussed here.

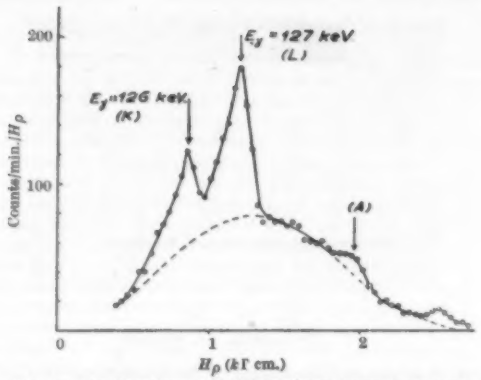

Fig. 1. The β-spectrum of ^{181}Hf (resolving power 4 per cent)

The measurements of the β-spectrum were repeated with the same spectrometer as formerly[1]. The resolving power was, however, increased to 4 per cent and the window thickness reduced to ~0·5 mgm./cm.^{2}. The β-spectrum is shown in Fig. 1. It will be seen that the conversion line (*A*) of the 342-keV. γ-quantum which could not be discerned in the previous measurement now appears distinctly. Otherwise the two spectra are in good agreement.

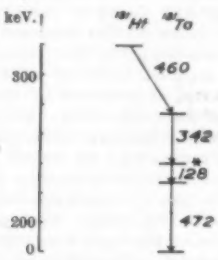

Fig. 2. Decay scheme of ^{181}Hf (all energy values given in keV.)

Delayed γγ-coincidence measurements were carried out in our standard arrangement[1], where a time-delay of ~ 10 μsec. was introduced in one channel. The sample was enclosed in a lead shield 1 mm. thick. The soft radiations (the unconverted 128-keV. γ-quantum and the corresponding X-radiation) were thus practically cut off. Under these conditions, a γγ-coincidence effect amounting to $(k_{\gamma\gamma}/n_\gamma) \times 10^3 = 7 \times 10^{-3}$ was found. This effect is about half the chance coincidence effect. The experiments were repeated many times, and the chance coincidence effect was checked, after each measurement, by ^{60}Co of the same counting-rate in the tubes. These results support the decay scheme given in our previous paper[1] and reproduced here in Fig. 2. The magnitude of the coincidence-rate is in agreement with that computed (from the geometry of the arrangement, the efficiency of the γ-tubes, the half-life of the metastable state and the delay and resolving times of the amplifier).

According to the conclusions of De Benedetti and McGowan[2] the metastable state should follow directly the β-transmission. This is not in agreement with our suggestion. The reason why they have not found any effect of the γ-ray which precedes the metastable state may be due to the fact that its energy is less than the one which follows the metastable state.

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[3] Cork, J. M., Shreffler, R. G., and Fowler, C. M., *Phys. Rev.*, **72**, 1209 (1947).

Errors of Treatment Comparisons when Observations are Missing

In a randomized block experiment with J blocks and K treatments, for which σ^2 is the variance of the random component of the observations and for which no observations are missing, the estimated difference of the means of two treatments has variance $2\sigma^2/J$. For the case where some observations are missing, Yates[1] has shown how the missing values may be estimated, a valid analysis of variance carried out, and an unbiased estimate of the difference of means of two treatments obtained. He has given the variance of this estimate for the case of only one missing observation, and has suggested an approximation for use in other cases which may be expressed as follows.

If J_A observations are present for treatment A, and j_A of these are in blocks which contain no observation for treatment B, and if J_B observations are present for treatment B, and j_B of these are in blocks which contain no observation for treatment A, then the variance of the estimate of the difference of means of A and B is $\theta_{AB}\sigma^2$, where

$$\theta_{AB} = \frac{1}{J_A - \frac{1}{2}j_A} + \frac{1}{J_B - \frac{1}{2}j_B}, \text{ approximately.}$$

I have derived exact formulæ for θ_{AB} for all cases where not more than three observations are missing, and have compared the exact and approximate values for a wide range of values of J and K. The agreement is reasonably good when K is small but poor when K is large. The formulæ suggest that a closer approximation would be given by

$$\theta_{AB} = \frac{1}{J_A - \frac{1}{K-1}j_A} + \frac{1}{J_B - \frac{1}{K-1}j_B},$$

and this is confirmed by numerical calculation. If not more than three observations are missing and J and K are both greater than 3, the error of the approximation only exceeds 4 per cent in a very few cases. These all occur either where there are three missing observations and $J = K = 4$, or where practically all observations of one treatment or one block are missing. In most cases the error is very much smaller than this.

In practical applications an analysis of variance would first be carried out to test if there were any significant differences between treatments. If so, any pair could be tested and would be judged to differ significantly if the difference of their means exceeded $t\sqrt{\theta}\,s$, where s^2 was the error mean square

with n degrees of freedom, and t was the appropriate percentage point of the t-distribution with n degrees of freedom.

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[1] Yates, F., *Emp. J. Exp. Agric.*, **1**, 129 (1933).

Development of Spark Discharges

IN a recent communication[1] concerning the mechanism of growth of the leader strokes preceding spark discharges, Allibone has stated that the leader stroke develops behind a voluminous corona discharge and that the concentrated bright streamer, which is readily photographed, is in the nature of a 'core' to this corona. The same view has been expressed by ourselves on various occasions and in earlier reports[2], and not only have we succeeded in demonstrating beyond doubt the existence of this diffuse corona discharge forming the head of the leader stroke, but we have also been making extensive investigations of its characteristics during the past eighteen months.

From consideration of the rotating camera records[3], which show the existence of diffuse corona discharges in association with the brighter filamentary streamers, it became clear to us some time ago that the photographic methods of observing the development of leader strokes have certain limitations and require to be supplemented by other techniques[4]. Allibone has referred to experiments made with Lichtenberg figures, but in such measurements, where stationary recording systems are used, it is difficult to determine the sequence of the processes observed, particularly because of the diffuse nature of the discharge. Similar difficulties occur in the interpretation of rotating camera photographs, where a distinction between spatial and temporal displacements is confused when the photographed object is diffuse.

Because of the various limitations of the photographic measurements, we decided to study the growth of leader strokes by arranging for the light emission from the discharge to fall on the sensitive cathode of a photomultiplier, the output from which is amplified and is reproduced on an oscillograph screen[5]. With this technique, a very high resolution in time is possible, of less than 10^{-7} sec., and the sensitivity to light is greater than that of a photographic emulsion. Further, the intensity of the light can be determined more accurately than in the photographic method, where there is a failure in the reciprocity law when light pulses of short duration are being recorded.

With this technique we have observed the corona discharge occurring in a discharge gap between a positive point and a negative plane, for impulse voltages below that required to cause breakdown. Under these conditions, for a 50-cm. gap in air at atmospheric pressure, the corona discharge produces a light pulse as shown in the oscillogram of Fig. 1. The corresponding current pulse in the gap is of the same shape. Both pulses rise to their peak amplitude in a time 5×10^{-8} sec. and decline to a small value after 4×10^{-7} sec. By the use of slits placed between the gap and the photomultiplier the light distribution with corona has been examined, and we have found that the light is emitted from a roughly hemispherical

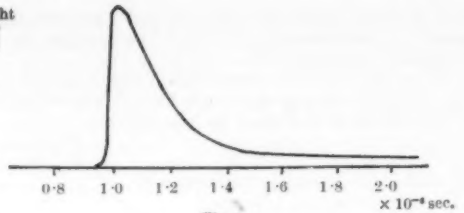

Fig. 1

volume, with the positive point at the centre of the plane face of the hemisphere, which is parallel to the negative plane, and with the curved face directed towards the plane. The light intensity decays continuously with distance from the point.

When the impulse voltage applied to the gap is raised to the breakdown value, or to higher values, a leader stroke develops from the point and initiates a spark. The growth of this leader stroke has been studied by placing between the gap and the photomultiplier an opaque screen containing a slit, the position of which can be altered, so that changes of light in different parts of the gap can be recorded. As the leader stroke passes the slit it produces an increase in the light reaching the photomultiplier through the slit, and consequently a deflexion is produced on the oscillograph screen. The occurrence of the main stroke also causes a deflexion, and from measurements of the amplitude of the various deflexions and the time intervals, both the distribution of light in the leader stroke and its speed of growth can be determined. A typical oscillogram is reproduced in Fig. 2. The discharge commences as an impulse corona which is too small to appear on this oscillogram. Afterwards the light intensity passing through the slit increases gradually as shown to a peak which corresponds to the passage of the 'core' of the leader stroke across the slit. The light then decreases rapidly to a small value and increases again very suddenly when the main stroke occurs. From this evidence it is clear that the leader stroke does not consist of a point source, as this would give a sharp light pulse of duration about 10^{-7} sec., but that it is formed by a diffuse discharge which increases in intensity to a central 'core'. The distribution of the light in the leader stroke, and its size, is generally similar in appearance to the impulse corona mentioned above. Emission of light can be detected up to a distance of the order of 10 cm. ahead of the central 'core'.

Besides the measurements of the light distribution, in space and time, the speed of the leader stroke at different stages in its growth across the gap has been determined, and the current flowing in the leader stroke has been recorded oscillographically. The investigations have been made in air, at atmospheric

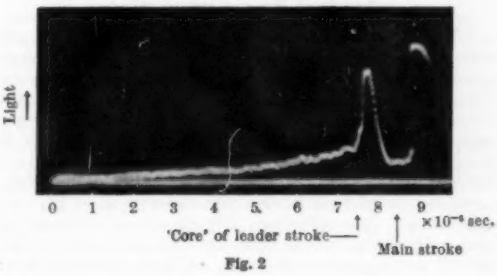

Fig. 2

and reduced pressures, and also in several other gases. A full account of these investigations will be published elsewhere.

We should like to acknowledge the financial support given to this work by the British Electrical and Allied Industries Research Association.

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[1] Allibone, *Nature*, **161**, 970 (1948).
[2] Saxe and Meek, Brit. Elect. and Allied Ind. Res. Assoc., Report Ref. L/T.183 (1947); Report Ref. L/T.188 (1947) (completed and revised accounts are in process of issue).
[3] Allibone and Meek, *Proc. Roy. Soc.*, **166**, 97 (1938); **169**, 246 (1938).
[4] Meek and Craggs, *Nature*, **152**, 538 (1943).
[5] Prime and Saxe, *J. Inst. Elect. Eng.* (in the press).

The object of my recent experiments[1] was to bring out photographically what we have known for many years. With an adequate background of visual observation of spark formation, there is no difficulty in determining in general terms the sequence of occurrence of the different kinds of discharge. As the voltage applied to a point/plane gap is increased, the corona extending therefrom increases (I would not have described the volume of discharge as hemispherical in shape; Fig. 5 in ref. 2 is a very typical shape for such a discharge), and near breakdown the concentrated bright streamers or leader strokes first become obvious extending over part of the gap as described in my communication in *Nature*[1]. The technique of chopping the spark with another spark gap in parallel enables the development of the leader stroke to be followed.

Prof. Meek and Mr. Saxe's technique will be invaluable in providing quantitative data on the corona and leader stroke currents and the light emitted by these discharges; but the facts they describe are well known though not well supported by photographs. The simple Lichtenberg figure technique which I have described gives the best photographic record of the leader stroke developing out of the corona discharge; it might even be more sensitive than the photomultiplier, because Fig. 2 of ref. 2 shows unmistakable evidence of corona one metre ahead of the leader stroke, whereas the multiplier has recorded light emission only 10 cm. ahead of the central core or leader stroke.

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[1] *Nature*, **161**, 970 (1948).
[2] *J. Inst. Elect. Eng.*, **32**, 513 (1928).

Internal Pair Conversion

When a γ-quantum, emitted from the nucleus of a radioactive atom, is absorbed by the same atomic system, an ordinary electron and a positron may be liberated if the energy of the γ-quantum is greater than $2mc^2$. This effect has been calculated by Jaeger and Hulme[1] on the assumption that the γ-ray is electric dipole or quadrupole radiation. I have performed the corresponding calculation for the magnetic dipole radiation and the element $Z = 84$. In calculating the coefficient, Dirac's exact wave equation of the electron is used and the process is interpreted as the transition of an ordinary electron from a negative energy to a positive energy state. The results are given in the accompanying table, where the energies are expressed in units of mc^2 and N is the number of positrons (which is, of course, equal to the number of the pairs created) per unit energy range.

Energy distribution of the electron pairs

$h\nu = 2{\cdot}62$ MeV.	$\frac{E_+ - 1}{h\nu - 2}$	0·159	0·383	0·612	0·840
	$N(h\nu-2)10^4$	7·10	9·70	14·9	26·2
$h\nu = 8{\cdot}00$ MeV.	$\frac{E_+ - 1}{h\nu - 2}$	0·073	0·366	0·635	0·926
	$N(h\nu-2)10^4$	31·3	48·8	77·6	58·7

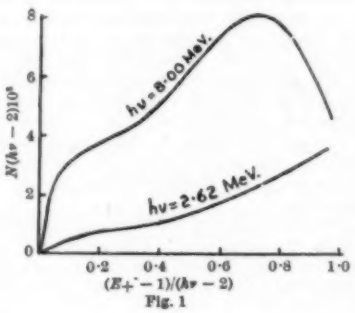

Fig. 1

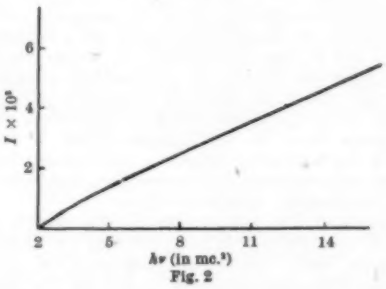

Fig. 2

In Fig. 1, $N(h\nu - 2)$ is plotted against $(E_+ - 1)/(h\nu - 2)$. The marked difference in the average energy of the electrons and positrons is due to the Coulomb forces acting on the two particles. Moreover, the curve, for $h\nu = 8{\cdot}00$ MeV., shows a maximum near the highest positron energy, as would be expected. By integrating over these curves, the coefficients of the internal pair conversion of the γ-rays are deduced. The results are:

$$I = 1{\cdot}5 \times 10^{-3} \text{ for } h\nu = 2{\cdot}62 \text{ MeV.},$$
$$\text{and } I = 5{\cdot}6 \times 10^{-3} \text{ for } h\nu = 8{\cdot}00 \text{ MeV.}$$

If we plot I against $h\nu$ (Fig. 2), it is found that a straight line connecting these two points nearly passes through the point ($I = 0$, $h\nu = 2mc^2$).

In conclusion, I want to express my gratitude to Mrs. B. Jeffreys and Dr. N. Kemmer for their valuable discussions.

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[1] *Proc. Roy. Soc.*, A, **148**, 708 (1935).

ISOLATION FROM ARGEMONE OIL OF DIHYDROSANGUINARINE AND SANGUINARINE: TOXICITY OF SANGUINARINE

By S. N. SARKAR
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ARGEMONE oil has received considerable attention during recent years on account of its alleged etiological role in epidemic dropsy[1-4]. I pointed out[5] certain anomalies of the mustard oil – argemone oil theory of epidemic dropsy and stressed the fact that a definite solution of the problem could only be arrived at by isolating the active principle from argemone oil and the suspected mustard oil, and then showing that these are chemically identical and possess similar toxic properties. Lal *et al.*[3] could not produce any satisfactory evidence on this aspect of the problem.

In a report of some preliminary work done, Sarkar and Rahman[6] stated that it was possible to precipitate the nitrogenous bases present in argemone oil as crystalline picrate, and from the crude picrate at least two fractions could be separated each of which when converted into the hydrochloride proved toxic to rats by oral administration, causing heavy mortalities. With the view of clearing up some of the important points, a detailed investigation was undertaken by me under the direction of Prof. R. A. Peters, and the relevant findings are reported here.

The main alkaloid of argemone oil has been purified by chromatographic analysis on an alumina column followed by crystallization from alcohol – benzene mixture. The purified compound (I), m.p. 190–91°, agreed in formula and properties with dihydrosanguinarine (found: C, 72·11; H, 4·54; N, 4·22; $C_{20}H_{15}O_4N$ requires C, 72·07; H, 4·51; N, 4·21 per cent). It is clear, therefore, that the formula $C_{19}H_{15}O_4N$ proposed for this compound by Mukherji, Lal and Mathur[7] is not correct. An authentic sample of dihydrosanguinarine obtained from the laboratory of the late Prof. Späth, when further purified by the present procedure, melted at 190–91°, and the mixed melting point with compound (I) did not show any depression.

Compound (I) could be readily oxidized by ferric chloride in presence of hydrochloric acid giving beautiful orange-red crystals of sanguinarine hydrochloride (II). This compound is identical with the compound obtained before in the ferric chloride test for the detection of argemone oil developed by me[6]. By the identification of the compound, the theoretical basis of the test is provided. Compound (II) was easily converted into the pseudo-cyanide, m.p. 238–39° (decomp.), and this could be reconverted into the original hydrochloride. The authentic sample of dihydrosanguinarine also behaved in the same way with ferric chloride.

Further confirmation came from the oxidation of compound (II) to oxysanguinarine, isolation of a zinc-dust distillation product, m.p. 135–135·5°, giving the fluorescence test of Graebe[8] and agreeing with the formula of α-naphthaphenanthridine, and also from the transformation of (I) into 3.4.6.7-tetramethoxy-11.12-dihydro-N-methyl-α-naphthaphenanthridine, m.p. 183–85°, and giving a mixed melting point, 182–84°, with an authentic sample, m.p. 181–83°.

Sanguinarine has been isolated from argemone oil by chromatographic analysis of the oil on a silica column, and also from the crude precipitate obtained by passing dry hydrogen chloride into an ethereal solution of the oil; the amount of sanguinarine hydrochloride obtained by the latter procedure is 0·44 mgm./c.c. of oil. In this sample of oil, dihydrosanguinarine accounted for about 87 per cent and sanguinarine for about 5 per cent of the total alkaloids present.

When sanguinarine hydrochloride was injected intraperitoneally to albino rats in a dose of 2 mgm./100 gm. body-weight, there was 100 per cent mortality. In contrast to this, dihydrosanguinarine at about two and a half times this dose, or oxysanguinarine at about four times this dose, did not kill any of the rats injected. Sanguinarine hydrochloride was also toxic when fed by mouth, and by following a suitable procedure, young albino rats (40–96 gm.) could be killed usually within a week by administering 1 mgm. of the poison daily.

In further studies of the toxic effects of sanguinarine, the eyes of two albino rats about to die from a lethal intraperitoneal dose of the hydrochloride were removed by Dr. Pirie and Dr. Jackson, and sectioned. The sections, compared with those from normal eyes, showed that there was great congestion of the capillaries of the iris, choroid and retina.

Sanguinarine hydrochloride is toxic to some enzyme systems also. It has been found, for example, that it can inhibit the oxidation of pyruvate, lactate and succinate by pigeon brain preparations. In fact, the effect on pyruvate oxidation was very marked, and with the pigeon brain homogenates used in this laboratory, about 30–35 per cent inhibition of the total oxygen uptake in presence of added pyruvate was noticed with 0·041 m*M* concentration of the poison. Addition of cocarboxylase could not prevent this inhibition.

The observed inhibition of pyruvate oxidation strongly suggests the possibility that there should be accumulation of pyruvate in the blood of persons suffering from dropsy due to argemone oil poisoning. This agrees very well with an observation of Wilson and Ghosh[10] that there was a significant rise in the bisulphite-binding capacity of the blood in epidemic dropsy cases. In a preliminary experiment carried out here, a definite rise in blood pyruvate has been noticed in rats after a heavy dose of sanguinarine hydrochloride intraperitoneally.

The inhibitory effect of sanguinarine hydrochloride on some —SH enzymes suggested the possibility that it was probably combining in some way with the essential —SH groups. This was confirmed by the observation that when B.A.L. or monothioethylene glycol was treated with an excess of sanguinarine hydrochloride at *p*H 7·4, there was a precipitate containing sulphur and the filtered solution gave negative nitroprusside test. It has not been possible as yet to purify these compounds; but analysis of a nearly pure compound with monothioethylene glycol confirms the presence of sulphur in the compound and indicates also that very probably one molecule of the base is combining with one molecule of thiol.

In vitro experiments with the pigeon brain homogenates showed that if mixed before, 50 μgm. of B.A.L. could completely protect the pyruvate oxidase system from the toxic effect of 100 μgm. of sanguinarine hydrochloride—even 20 μgm. of B.A.L. could afford about 70 per cent protection. However, B.A.L. could not reactivate the already poisoned enzyme.

These results were confirmed by *in vivo* experiments. When albino rats were injected with an excess of B.A.L. (intramuscularly) 15–20 minutes before the administration of a lethal dose of the poison (2 mgm./100 gm., intraperitoneally), there was almost complete protection and about 85 per cent of the treated rats survived.

Since B.A.L. will not reverse the *in vitro* damage to enzymes, it is unlikely to reverse any toxic effects already established by sanguinarine, but it might be useful in preventing further damage due to any unreacted poison.

The poisonous nature of sanguinarine was known before and its pharmacological effects were studied by Meyer[11].

A detailed account of the work will be published at an early date.

My grateful thanks are due to Prof. R. A. Peters for his continued interest and help and for the facilities provided. I am indebted to Dr. A. Pirie and Dr. C. R. S. Jackson for examining the eyes of some of the experimental rats, to Prof. L. Ebert for samples of dihydrosanguinarine, sanguinarine nitrate and the tetramethoxy compound, to Dr. L. A. Stocken for the sample of B.A.L. and to Prof. S. N. Bose for the argemone oil. My thanks are also due to the Government of India for a research grant, and to the Carnegie Grants Committee of the University of Oxford for some financial help.

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[2] Lal *et al.*, *Ind. J. Med. Res.*, **27**, 207 (1939); **28**, 163 (1940); **29**, 157, 167, 813, 839 (1941).
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[5] Sarkar, *Ann. Biochem. Exp. Med.*, **1**, 59, 204 (1941).
[6] Sarkar and Rahman, *Curr. Sci.*, **14**, 196, 200 (1945).
[7] Mukherji *et al.*, *Ind. J. Med. Res.*, **29**, 361 (1941).
[8] Sarkar, *Ann. Biochem. Exp. Med.*, **1**, 271 (1941); **2**, 101 (1941).
[9] Graebe, *Annalen*, **335**, 127 (1904).
[10] Wilson and Ghosh, *Ind. Med. Gaz.*, **72**, 147 (1937).
[11] Meyer, *Arch. Exp. Path. Pharm.*, 397 (1892).

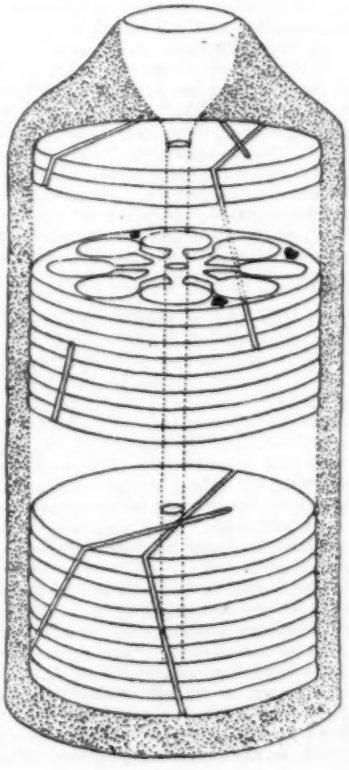
THE TECHNIQUE OF CASTING COINS IN ANCIENT INDIA

THE chance discovery by Prof. Birbal Sahni at Rohtak, some forty miles west-north-west of Delhi, in 1936, of a clay mould for the casting of a coin, later led to the discovery of many thousands of fragments of similar moulds. The bronze coin, about 19 mm. in diameter, of the Yaudheya series, has been dated about 100 B.C. From the very large amount of material available, Prof. Sahni has been able to work out in the greatest detail the entire story of the casting technique employed[1].

The accompanying figure illustrates the manner in which the mould was constructed. A pouring basin at the top leads to a central vertical runner, 7 mm. in diameter, from which, at successive levels, eight radial runners communicate with moulds for the same number of coins. The disks containing these moulds were 87 mm. in diameter and were built up into a pile, perhaps a foot or so in height. Around this there was a jacket of clay admixed with fragments of unhusked grain. When the mould was complete it was heated up to a surface temperature of the order of 600°–650° C., as a result of which the organic material was charred, leaving the jacket in a porous condition through which the gases could escape.

There can be little doubt that the moulding technique was carried out in the following manner. Around a wooden baseboard of the same diameter as the disks, and with a central peg 7 mm. thick fixed in the centre, a cylindrical container was placed, and a slab of plastic clay, sufficient for one disk, introduced. On this the side runners were first moulded from an 8-spoked metal pattern about 1½ mm. thick. At the ends of the spokes the coin moulds were pressed into the clay, a very large number of such patterns being employed, and any obstruction between the individual runners and the mould being removed. This disk was then dusted with a parting powder, such, for example, as wood-ash, and a second one prepared on top. In order to ensure exact register of the two surfaces of the disks, small irregular fragments of stone or brick were introduced into the lower disk while still plastic, producing a corresponding depression in the overlying surface. In this way a set of up to a dozen disks was produced, the upper and lower surfaces of each complete set being blank. On the removal of the surrounding cylinder, an oblique groove was marked across the upper surface of the disks and obliquely down the side. In most cases two such grooves are marked and the re-assembly of the disks (after drying) in their correct order thus facilitated. After air drying, the disks were re-assembled and a series of sets piled one on another to produce a mould of appropriate size.

This, after being covered with the jacket, was baked in some sort of furnace and the casting carried out while the mould was still hot, probably while still in the fire, with the pouring basin alone exposed.



When cold the mould was broken open and the coins broken away from the runners. The author suggests that on one of the two opposing faces an obstruction was often deliberately left between the side runner and the coin mould, providing a small notch which enabled the coin the more easily to be detached.

The question as to whether this coin foundry was legitimate or not is discussed by the author, who concludes—possibly on somewhat scanty evidence—that these moulds were not, in fact, the product of a forger. Whether this be so or not is quite immaterial, however, from the point of view of the most interesting information provided regarding a technique employed at this very early date. A comparison is also made with other conjectured reconstructions of Indian and other coin moulds of different dates and localities. In the latter cases, however, more material is needed to settle the details of the process with the same certainty which has been possible in the case of the Rohtak procedure. To the metallurgist and numismatist alike, this contribution is one of outstanding interest. F. C. THOMPSON

[1] "Memoirs of the Numismatic Society of India", No. 1, Bombay, 1945.

ATOMIC ENERGY EXHIBITION: THE ATOM TRAIN

AFTER a tour lasting six and a half months, during which the Atomic Energy Exhibition, organised by the Atomic Scientists' Association, visited twenty-five of the main centres in England, Scotland and Wales, the exhibition came to a close on May 28. Efforts to secure an extension in Great Britain failed; but the exhibition will continue its existence abroad. The Council of the Atomic Scientists' Association, as well as the Ministry of Supply and other owners of equipment, have agreed to lend the exhibits to the United Nations Educational, Scientific and Cultural Organisation and the Lebanese Government for incorporation in an exhibition at the Unesco Conference in Beirut in October. Later it will probably tour several countries in the Middle East and, possibly, various European countries. Although the administration of the tour is left to Unesco, the Atomic Scientists' Association will be closely connected with it, and the atomic energy part of the exhibition will be known as that of the British Atomic Scientists' Association.

In Great Britain the exhibition was an outstanding success and excelled all hopes. It was visited by more than 146,000 people, making an average daily attendance of 1,000, which is 80 per cent of the maximum capacity. In many places people were queueing up for several hours. 85 per cent of the visitors came especially to see the exhibition, many of them making long trips for this purpose.

The reaction of the public was learnt from the answers of more than 1,100 people to a questionnaire handed out to a random sample of visitors. They show that the visitors represented a fair cross-section of the British public as regards occupations, with a slight bias in favour of the intellectual classes. 95 per cent of the public thought it worth while coming, and 91 per cent said that they had learnt something from the exhibition. The most interesting parts were found to be the counters and models (32 per cent) and the peaceful uses (24 per cent); the atom bomb section was the main item of interest for only 7 per cent. Quite a large number of people expressed surprise that atomic energy could be used for constructive purposes as well. The main criticism of the exhibition was that it was not big enough and too crowded.

The guide book to the exhibition sold extremely well. Altogether more than 50,000 copies were sold or presented, making it the most popular and widespread publication on atomic energy.

The performance of the technical equipment, most of which was very delicate and tricky to operate, was extremely satisfying. Some of the experiments were demonstrated publicly for the first time and only a few years ago could not have been made to work reliably even with the best care in the laboratory. Here they were subjected to the most adverse conditions, to the movement of the train on a 1,900-mile journey, to differences of temperature ranging from 30° to 100° F., to a wide range of voltages in the various places and, above all, to the heavy hands of about 130,000 adults and 16,000 inquisitive children.

Not only has the equipment withstood the test magnificently, but also it has beaten all records for endurance of this type of apparatus. The scaling units are supposed to have a life-time of 200 hours, and yet during the 1,600 hours of operation of five scaling units, only one valve had to be replaced. Throughout the whole tour, each Geiger counter had to be replaced only once. The total time when the exhibits were out of commission amounted to less than 1 per cent and the total expenditure on maintenance of equipment, including replacement of films, fluorescent tubes, etc., was less than £50.

All this is evidence of the good quality and high-class workmanship of the British firms who manufactured it; it is also a tribute to the technical staff who looked so well after the maintenance of the equipment.

The Atomic Energy Weeks, which were organised in conjunction with the exhibition, were also very successful and the lectures and film shows were well attended.

Summing up, it can be concluded that the exhibition achieved its main object—that of educating an appreciable fraction of the British public in matters of atomic energy.

ROTHAMSTED EXPERIMENTAL STATION

REPORT FOR 1946

THE return to peace-time activities at Rothamsted Experimental Station enabled much of the fundamental and long-range work to be resumed, and the report for 1946 now issued includes a short account of such investigations, as well as of new work undertaken by the various departments. There are departments of physics, chemistry, soil microbiology, botany, crop physiology, statistics, plant pathology, biochemistry, entomology, insecticides and fungicides, and one for the study of bees. This list of departments indicates the very wide scope of the work at Rothamsted, and it is impossible not to be impressed by the advantages that must accrue from the ready contacts that are possible between the workers in the various sections. The experimental farm, together with that of Woburn, one on heavy and the other on light soil, offers every facility to the

research worker, and the work of the Statistical Department enables field-work to be carried out with the maximum of effect. Field-work is not confined to the two farms, many careful experiments being carried out at various centres in the country; thus the main set of tests on the manuring of sugar beet, for example, involves some twenty commercial farms annually.

In a note of this length, it would be impossible to do justice to the work of so many departments; a reviewer can but mention one or two out of many significant lines of work. The experiments on deep ploughing and on cultivations have interested scientific men and farmers for some years, and the resumption of this work is welcomed. Results available before the War indicated that much time and money are lost on the farms of Britain in excessive cultivations; but farmers and Rothamsted workers alike felt that such unexpected results needed more corroboration. It has generally been considered that, in so far as yield of crop is concerned, the more and the deeper the cultivation the better; we used to point out the large, if expensive, crops raised in some gardens, where trenching is carried out, etc., and where no expense is spared on the preparation of the seed bed. The work at Rothamsted, however, which included experiments at many centres in 1944 and 1945, did not indicate any advantage from deep ploughing or from sub-soiling for potatoes or beet, and very little for wheat. Observations of root development and of the physical properties of the soil showed that none of the properties was influenced by deep cultivation.

The theoretical and experimental work on the movement of water in soils, and on evaporation, is also of great interest. Most of us have had the experience of observing small patches of a crop that have made far better growth than that of the surrounding plants, due to some physical character of those portions of the seed bed; for example, consolidation as the result of pressure from a tractor wheel, or greater pulverization on a headland where some implement may have been turned round, and where upward movement of water in the soil was presumably facilitated. On other occasions, under different weather conditions, these excessively consolidated or pulverized areas have carried the poorest plants. It is not easy for even the most experienced farmer to achieve the optimum seed-bed condition every season, and there will always be an element of chance about this until more fundamental knowledge is available about the physical properties of the soil, particularly in regard to water.

The Department of Chemistry commenced work in 1945 on forest nurseries, and interesting results are already available. It is interesting to note, for example, how the growth of Sitka spruce was improved by acidifying a slightly calcareous soil on which this species had consistently failed for a number of years. Work already carried out is sufficient to indicate that fruitful lines of research lie ahead in this field.

Work carried out in the Department of Soil Microbiology on the micro-organisms capable of the selective destruction of soil bacteria may be noted as of particular interest. The maintenance of satisfactory biochemical activity in a field soil depends on several factors, not the least important of which is the existence of micro-organisms that limit the numbers of useful organisms, either by competing with them for nutrients, or by producing toxic secretions, or by directly eating them. A number of strains of bacteria were subjected to attacks by five predatory organisms, and by three species that are destructive to bacteria by virtue of their secretions. It was found that any one species of organism could attack about half the bacterial species tested; the organisms, however, differed markedly as to which particular bacterial strain they attacked. It seems likely that very few species of bacteria exist in the soil that are immune to attack by some of the micro-organisms.

Current advances in the use of insecticides lend great interest to the Rothamsted investigations in that field. Experiments are in progress on various aspects of the use of D.D.T. and of benzene hexachloride, including the effect of these on bees.

Tables giving the detailed results of the experimental work have been omitted, since it is intended to issue these separately. The report includes a list of the scientific papers from each department, with a short note on the contents of each, and also a list of the publications of the Rothamsted Experimental Station.

PACIFIC SCIENCE BOARD

FIRST ANNUAL REPORT

THE first annual report of the Pacific Science Board (National Research Council, Washington 25), set up as a result of the Pacific Science Conference, 1946, covers the year 1947, and outlines the steps being taken under the project for the co-ordinated investigation of Micronesian anthropology to fill gaps in our scientific knowledge of the Marshall, Caroline and Mariana Islands, and to provide the basic information required in setting up civilian government in these trust territories of the United States. A permanent Insect Control Committee has been appointed for Micronesia, and five entomologists have been sent to survey the distribution and destruction of coco-nut palms caused by the rhinoceros beetle (*Oryctes rhinoceros*), to study the coco-nut beetle (*Brontispa mariana*) and the giant African snail (*Achatina fulica*) and to search for parasites or natural enemies for the control of these pests. An entomological survey of the Palau Islands is also in progress.

Approval was given for eight other field projects, and in general the Board's policy is to give stronger endorsement and higher priority to proposals for intensive and long-range research than to those for extensive but superficial surveys or short-term projects. In accordance with the desire to strengthen Honolulu as a centre for research in the Pacific, the Board generally recommends that reference collections from the area should be deposited with appropriate institutions in Honolulu.

The Pacific oceanic biology project is now actively engaged in studying, analysing and evaluating the data already available, with headquarters at the Woods Hole Oceanographic Institution; and plans are now being developed for establishing a new Hawaii Marine Laboratory on an island in Kaneohe Bay, Oahu. The Board also hopes to co-operate with the research council to be set up by the South Pacific Commission in developing plans for research in that area, and conservation planning in the Pacific should be greatly assisted by three forthcoming international conferences: the meeting of the Standing Committee for the Protection of Nature in and around the Pacific, at the Seventh Pacific Science Congress to

be held in New Zealand in February 1949; the Economic and Social Council of the United Nations Scientific Conference on the Conservation and Utilisation of Resources, to be held in the United States in May 1949; and the United Nations Educational, Scientific and Cultural Organisation's Conference on the Protection of Nature also to be held in the United States in May 1949.

Future activities contemplated include the encouragement of oceanographic and fisheries research in various parts of the Pacific, the initiation of a conservation programme for Micronesia, and the initiation of field studies in the Pacific area to further research bearing on problems in cancer and heart disease.

CARNEGIE UNITED KINGDOM TRUST

THE thirty-fourth annual report of the Carnegie United Kingdom Trust for the year 1947 emphasizes the increasing rate of expenditure, which rose from £120,000 in 1946 to £160,000 in 1947, thus exceeding the annual expendable income of about £133,000. The quinquennial policy for 1946–50 was framed on the assumption, however, that during the period a substantial part of the accumulated savings of the war years would be applied as annual revenue, and the Trustees are more concerned at a second feature of the period—the increasing proportion of expenditure allocated to the provision of services rather than buildings or capital assets.

The largest bulk allocations, totalling £150,000 each, for the Bureau of Current Affairs and for the development of amateur music and art, are wholly concerned with services, and this is also true of the £25,000 allocated to enable local organisers to be appointed by County Federations of Young Farmers' Clubs. Although the 'village hall' allocation of £100,000 is designed to help capital expenditure, payments have amounted to less than £7,500 in two years. Past experience of the Trustees indicates that grants for capital purposes have been more certain in their operation than grants for the early maintenance of services, and accordingly they regret the present restricted opportunities in the capital field. In view of the unsatisfactory position of the village halls scheme, it has been decided that when the Trust allocation of £100,000 has been exhausted by promises, subsequent schemes shall be eligible for consideration for Exchequer grants under the Physical Training and Recreation Act. For the village planning competition, forty-seven entries were received and the winning design is regarded by the adjudicators as quite outstanding. The Trust has also agreed to find up to £400 a year for a two-year programme of pioneer work for young women from the Channel Islands, partly by visits of expert organisers from England and partly by courses of instruction in England.

The report refers to the passing of the Irish Central Library for Students under an independent governing body, the Library Council established by the Public Libraries Act of 1947 (Eire). Grants to three county libraries in Eire have also been agreed in principle, and the committee set up to consider the future of the Scottish Central Library reported unanimously in September 1947 that the Library should not be merged with the National Central Library, although continuing to work in the closest co-operation and consultation with that Library. Some form of constitutional link between the two Libraries was recommended; but it was considered that the time was now ripe for establishing the Scottish Central Library on an independent basis, with its own trustees and governing body and an initial income of £5,000, in new premises in Edinburgh. The grant to the National Central Library has been progressively decreased to £3,000, £2,000 and £1,000 for the three ensuing years and will become extinct on December 31, 1950.

Sufficient progress has been made with the Shropshire Community House at Attingham Hall, near Shrewsbury, to justify the appointment of a warden, and the Highlands and Islands Film Guild has made a very satisfactory start and is now working on a programme of six mobile film units.

STANDARD FREQUENCY TRANSMISSIONS IN GREAT BRITAIN

THE question of radiating standard frequency transmissions from Great Britain has recently been under consideration. Such transmissions are of great value in connexion with the calibration of industrial and scientific frequency sub-standards, in connexion with work on radio wave propagation and also for survey purposes. At present, standard frequency transmissions of guaranteed accuracy are emitted by the U.S. National Bureau of Standards[1] continuously on the eight frequencies 2·5, 5, 10, 15, 20, 25, 30 and 35 Mc./s. from station WWV. Unfortunately, on account of radio propagation conditions, it is often difficult to make good use of the American transmissions in Europe and farther east. At the recent meeting of the International Telecommunications Union at Atlantic City, it was agreed that the first six of the above frequencies (namely, 2·5, 5, 10, 15, 20 and 25 Mc./s.) should be allocated on a world-wide basis for all future standard frequency transmissions. Hence, if undesirable interference between such transmissions is to be avoided, all new services of standard frequency transmissions will require very careful co-ordination with existing services.

In Great Britain, an experimental low-power transmission from station GMT, on a frequency of 2 Mc./s., has been set up by the Royal Observatory at Abinger, Surrey, to facilitate comparisons between quartz clocks used in the operation of the Greenwich time service. Details of this service have been published recently[2]. Since no other British standard frequency service is at present available, these transmissions have been fairly widely used, and a substantial increase in power is under consideration.

In existing circumstances the provision in Britain of a comprehensive service on a number of the available frequencies will take some considerable time; but arrangements are now under consideration whereby a limited standard frequency service on three frequencies will be operated by the General Post Office. It is hoped that experiments connected with the new service will demonstrate the feasibility and value of covering the United Kingdom and Europe in this way, and also the degree of interference from and with the WWV transmissions.

Details of this experimental service will be announced later; but meanwhile it may be mentioned that the frequencies of the following transmitters of the General Post Office and of the B.B.C. are maintained at their nominal values to a tolerance better than ± 1 part in 10^6.

Station's call sign	Nature of service	Location	Nominal frequency kc./s.
GBR	Telegraph	Rugby	16
—	Broadcast	Droitwich	200
GRO	Broadcast	Skelton	6,180
GSB	Broadcast	Daventry	9,510
GSV	Broadcast	Daventry	17,810

The B.B.C. medium-wave transmitters, with the exception of that on 583 kc./s. (514 m.), are also maintained on their nominal frequencies to a tolerance of approximately ± 1 part in 10^6.

[1] National Bureau of Standards (U.S.A.). Letter Circular LC886, January 30, 1948.
[2] *Wireless World*, **53**, 439 (Nov., 1947).

ELECTRIC CONDUCTIVITY OF ROCKS AT HIGH TEMPERATURES

H. P. COSTER has described the results of measurements of the electric conductivities of various rocks (*Mon. Not. Roy. Astro. Soc.*, Geophys. Supp., **5**, No. 6, January 1948). The conductivity was determined on specimens of rock cut in the shape of a cylinder, by measuring the resistance between the electrodes in a D.C. bridge circuit; the current in the bridge was reversed after balancing, with the object of detecting potentials due to polarization of the rock by electrolysis. Although a small effect was usually found, its influence on the resistance was never more than a few per cent. The conductivities determined for different rocks showed that they could be classified as semi-conductors, and in many semi-conductors the relation between the conductivity and the absolute temperature T is given by

$$\sigma = A_1 \exp(-\varepsilon_1/kT) + A_2 \exp(-\varepsilon_2/kT) + \ldots,$$

where k is Boltzmann's constant, $\varepsilon_1, \varepsilon_2$, etc., are the activation energies of the various processes to which the conductivity is due, and A_1, A_2, etc., are constants.

The results of the experiments are shown graphically, $\log_{10}\sigma$ being plotted against $10^3/T$, for eight different rocks—all Scottish—which Prof. C. E. Tilley placed at the disposal of the author. The curves show that the conductivity of most of the rocks is due to at least two mechanisms: one with an activation energy of about 0·7 volt and the other with an activation energy of the order of 2 volts, the latter appearing at higher temperatures; experiments on the nature of the conductivity suggest that in this case it is caused by moving ions.

The theoretical implications of the results with regard to the conductivity in the interior of the earth are discussed, and the following suggestions are made. At a depth of a few kilometres where the rocks are probably dry, the conductivity is lower than it is nearer the surface; but as greater depths are reached, where the temperature is higher, the conductivity should start to increase. Assuming that pressure has no effect on the conductivity, a value of 0·01 ohm^{-1} cm.$^{-1}$ should be reached at a temperature of 1,200–1,400° C., possibly at a depth of 160 km. The effect of pressure is, however, a serious source of uncertainty in the investigation; but using the temperatures and pressures given by Bullard and Bullen, respectively, Coster has compiled a table which shows the variation of temperature, pressure and conductivity with depth, though the relation cannot be regarded as anything more than an approximation. At depths greater than 200 km. the increase in conductivity is rather small, because the effect of increase in temperature is almost compensated by that of increase in pressure. The figures, though giving only a rough idea of the variation of conductivity with depth, nevertheless can account for the increase of conductivity with depth found by Chapman and Price.

MEXICAN VILLAGE LIFE

THE monograph under notice*, the sixth of a series dealing with the sociology of Latin America, returns to the Mexican Highlands and to the Tarascan pueblo of Tzintzunzan. This village, which at the time of the Spanish conquest was the capital of an empire second only to the Aztec in size, has now become a sleepy Mestizo community of 1,500 souls which is "probably typical of a vast number of small rural Mexican pueblos". "Empire's Children" is a very readable account of this engaging and happy-go-lucky community of potters and farmers where "the great majority of the villagers get down to work only with a tremendous exertion of will power and stop on the slightest pretext", and where "Russia, Communism, the United States and Protestantism are conveniently lumped together as enemies of the inalienable rights of man".

The author's purpose is to convey a general and comprehensive impression of the social and economic life of these people, and he has been more than usually successful in achieving this. The reader is neither overwhelmed with masses of unnecessary detail nor mystified by technical anthropological jargon, and yet practically every aspect of village life is covered—its history and prehistory, its domestic and its material culture, its trade and commerce and its social, political and religious institutions. His summing up and conclusions are not so impressive, probably because of his short acquaintance with the country (two years) and possibly because although he admits the essential unity of the Mestizo culture, he remains too preoccupied in distinguishing the Spanish and Tarascan traits which contribute to its 'total configuration'. However, this summary only takes up eight pages at the end of the monograph and is probably inserted for the benefit of the Mexican Government rather than for the general reader.

It is to be hoped that this preliminary survey will be succeeded by detailed studies of the more striking aspects of rural Mexican society, in particular, of the part played by the Church, a role so vital that Foster considers it the "socio-spiritual focal point of the culture".

G. I. JONES

* Empire's Children. The People of Tzintzunzan. By George M. Foster assisted by Gabriel Ospina. Pp. v+297+16 plates. (Pub. No. 6, Institute of Social Anthropology, Smithsonian Institution, Washington, D.C.)

See also *Nature*, **161**, 697 (1948) for notice of Pub. 2–5 of this series.

SOIL IMPROVEMENT FOR FORESTRY

THE Reports of the Forest Research Institute of Sweden, Vol. 36 (Centraltryckeriet, Esselte AB, Stockholm, 1948) contains papers of considerable interest. Omitting those dealing with volume and other measurements made in different parts of the country, sample plots and yield tables, and papers on forest pests, an article of importance to other countries is that of Carl Olof Tamm entitled "Soil-improving Measures Tried on a Poor Site". The work is described as a final report on work started in 1922 by the Swedish Institute of Forest Research in co-operation with the Forest Protection Board of the district of Jönköping, following an initiative taken by W. Lothigius, who was at that time the Board's executive forest officer. The aim of the work has been to try some possibilities of raising the poor forest yield frequently found on sandy soils within the district and elsewhere in the province of Smaland. Earlier reports have been published by O. Tamm, who planned the experiments and was responsible for collecting data on the plots as long as he remained with the Institute (up to 1938).

The plots are at lat. 57° 34′ N., long. 22° 12′ E. They occupy an area known as the Mölna Field on a sand flat that was formerly mostly covered by old forest. In the experimental field, the forest was felled during 1918–19.

After describing the area and its previous vegetative covering, the methods of re-afforestation are treated by means of a number of experimental plots. Nine strips were laid out, numbered III–XI, each 50 mm. wide. Furthermore, the main experiment is divided in ten rows, crossing the strips at right angles. Row No. 7 is 37·5 m. wide, Row No. 8 is 62·5 m.; all other rows are 25 m. wide.

Strips Nos. III and V were sown in 1923 with pine mixed with spruce. In strip No. III the mor cover around each seedspot was loosened and mixed with the sand: no positive effect of this treatment was ever observed. At the same time, strip No. IV was planted with birch (about 1,000 per hectare, side-hole planting) and then sown with pine mixed with spruce. Strip No. VI was planted with *Alnus incana* instead of birch, and sown with pine.

Strip No. VII and the following strips were planted in 1922, the former with pine 1/0 and spruce 2/0 (ratio 2 : 1), No. VIII with birch as No. IV and pine and spruce, No. IX with pine and spruce, No. X with *Alnus incana* as No. VI and pine, and No. XI with pine only. The conifer seedlings were planted by the slit method.

The number of seedspots per hectare was intended to be 6,000 all over the field, but this figure is rather approximate. All pine and spruce seed used came from the same province; but the birch and *Alnus incana* seedlings originated from Bastad (Skåne).

In Strip No. VII each planting hole was manured with peat from a birch carr; seven or eight litres of peat were mixed with the earth in each hole before planting. The other treatments were done in different rows. The rows Nos. 1, 3, 5 and 7 were controls (no treatment). Within rows Nos. 2 and 6 the soil was ripped by a kind of harrow. Within row No. 4 about 400 gm. lime (calcium carbonate was used from the sulphate mill at Gotafors) was mixed in each hole. Within rows Nos. 8 and 10 tree-debris from the clear felling were removed and taken to row No. 9.

Most of the pines, planted or sown, grew well in the first few following years. The planted spruces grew well, too; but the spruce seed used had a poor capacity of germination. The birches and alder seedlings generally did not stand the hard conditions at Molna Field, especially the frosty climate. Within small areas seedlings of all kinds suffered, either from fungus injuries or from starvation. Attempts were made to fill blanks by repair plantings in 1926 and 1930.

Two diagrams give results from observations in 1932. The brush-manured row (No. 9) had a small number of seedlings but a high percentage of good pine. Many seedlings were spoiled by capercailzies that found shelter in the brush cover. The peat strip (No. VII) showed a slight excess over the others, both in number of seedlings and in percentage of good pine. None of these deviations is significant.

The paper should be consulted for full details. In summing up, the author writes: "The Mölna experiment has been helpful in drawing attention to some factors determining forest yield on poor sandy soils. Yet, in order to have a more definite idea of the parts played by humus conditions, on one hand, and by geology on the other, fresh data must be obtained on plots where the conditions at the start of the experiments are carefully determined. The problems at issue have proved much more complicated than was realized in 1920."

SOME FUNGI OF INDIA

SIX new species of fungi occurring in Mysore have been described by M. J. Thirmulachar (*Trans. Brit. Mycol. Soc.*, **31**, 1; July 1947). *Sphaceloma santali* attacks the leaves of the sandal tree; *S. osyridis* parasitizes leaves of *Osyris Wightiana*; *S. oleanderi* produces an anthracnose on oleander, and *S. curcumæ* causes leaf-spot of wild turmerics. *Cladochytrium aneuræ* is an interesting species weakly parasitic within the thallus of a liverwort (*Aneura* sp.), and *Leptosphæria porellæ* causes wilting of the bryophyte *Porella*. Mycological descriptions of the new species are given. Two further new species of *Physalospora* attacking *Pterolobium indicum* and *Heterostemma tanjorense*, two species of *Septoria* parasitizing *Erythrina* sp. and *Thespesia populnea*, with *Cercospora adinæ* on its name host, are fully described by T. S. and K. Ramakrishnan (*Proc. Ind. Acad. Sci.*, B, **26**, No. 1, 7; July 1947).

Several papers have also been published on *Phytophthora palmivora*, which causes a fruit rot of tomatoes and a seedling blight of *Hibiscus esculentus*. T. S. Ramakrishnan and C. K. Soumini have studied the fungus on tomatoes (*Proc. Ind. Acad. Sci.*, B, **25**, No. 2, 39; Feb. 1947). They isolated the fungus, proved its pathogenicity, found it could enter unwounded fruits, and, as infection appears most readily on fruits in contact with the soil, suggested proper support of tomato plants as a simple means of prevention. M. S. Balakrishnan (*Proc. Ind. Acad. Sci.*, B, **26**, No. 4, 142; Oct. 1947) established the pathogenicity of *P. palmivora* on *Hibiscus* seedlings. A minus strain was isolated, and did not form oospores until paired with a plus strain of the same species. Further studies on this heterothallism have been made by K. M. Thomas, T. S. Ramakrishnan, C. K. Soumini and M. S. Balakrishnan (*Proc. Ind. Acad. Sci.*, B, **26**, 147; Oct. 1947).

R. P. Asthana has investigated several characters of *Sclerotium cepivorum* and *S. tuliparum* (*Proc. Ind.*

Acad. Sci., B, **26**, No. 3, 93; Sept. 1947). *S. cepivorum* grows best on an acid medium, whereas *S. tuliparum* favours neutral or slightly alkaline conditions. Both species have an optimum temperature of 20° C. Neither species is able to attack the host of the other; but *S. tuliparum* can infect several bulbous plants in addition to the tulip. Both species secrete pectinase, though there is evidence that each host type is more sensitive to the enzyme of its specific parasite than to that from the other.

A threefold chain of parasitism is described by S. Y. Padmanabhan (*Proc. Ind. Acad. Sci.*, B, **26**, No. 3, 77; Sept. 1947), who found a species of *Fusarium* attacking pupæ of *Epipyrops*, which in the larval stage is a parasite of *Pyrilla*, a pest of sugar-cane. The fungus is variable in culture, but is regarded as *F. moniliforme* var. *subglutinans*. Six new hosts of the ergot fungus *Claviceps* are given by T. S. Ramakrishnan (*Proc. Ind. Acad. Sci.*, B, **26**, No. 4, 136; Oct. 1947), who also describes the fungus upon each. Miss H. Sunanda Kamath investigated the life-history of *Puccinia ruelliæ* on *Ruellia prostrata*, a common perennial weed in south India. It was found to be a macro-cyclic, autœcious rust, and the sequence of development of all the spore forms was followed by inoculation experiments.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER IN BOTANY—The Registrar, The University, Nottingham (August 21).

DAVID BROWN SCHOLARSHIP IN AGRICULTURAL ENGINEERING—The Registrar, King's College, Newcastle-upon-Tyne (August 21).

PAINT AND VEGETABLE OIL CHEMIST (graduate) to take charge of research and to teach a small post-graduate class, and a GRADUATE TECHNOLOGIST to teach vegetable oil extracting and paint manufacturing processes, at the Instituto de Oleos, Rio de Janeiro—The Director, Personnel Department, British Council, 3 Hanover Street, London, W.1 (August 21).

PHYSIOLOGIST (male) with an Honours degree in Science, and a BACTERIOLOGIST with Honours degree, or an Honours Graduate in Science with experience in Bacteriology—The Secretary, Hannah Dairy Research Institute, Kirkhill, Ayr (August 21).

LECTURER (man or woman) IN AGRICULTURAL SCIENCES at the Cheshire School of Agriculture, Reaseheath—The Director of Education, County Education Offices, City Road, Chester (August 21).

FORD MOTOR COMPANY SCHOLARSHIPS IN AGRICULTURAL ENGINEERING—The Registrar, King's College, Newcastle-upon-Tyne (August 21).

LECTURER (Grade III) IN THE DEPARTMENT OF GEOGRAPHY (with special qualifications in Meteorology and/or Geomorphology)—The Clerk, Birkbeck College, Breams Buildings, London, E.C.4 (August 21).

DEMONSTRATOR OF PHYSICS—The Dean, Medical School, Guy's Hospital, London, S.E.1 (August 23).

SCIENTIFIC OFFICER (Zoologist, for work especially on plankton) at the Millport Laboratory—The Secretary, Scottish Marine Biological Association, 185 St. Vincent Street, Glasgow, C.2 (August 24).

LECTURER or ASSISTANT LECTURER IN STRUCTURAL ENGINEERING—The Registrar, College of Technology, Manchester 1 (August 30).

ASSISTANT IN ZOOLOGY FOR RESEARCH IN ENTOMOLOGY, with minor teaching duties—The Secretary of University Court, The University, Glasgow (August 31).

AGRICULTURIST IN THE SOUTHERN RHODESIA GOVERNMENT SERVICE—The Office of the High Commissioner for Southern Rhodesia, 429 Strand, London, W.C.2 (August 31).

LECTURER IN CHEMISTRY with special qualification in physical chemistry—The Secretary, The University, Old College, South Bridge, Edinburgh (September 1).

LECTURERS IN MATHEMATICS, and LECTURERS IN SCIENCE (physics, mechanical or electrical engineering, or chemistry), at the Royal Military Academy, Sandhurst—The Secretary, Civil Service Commission, Burlington Gardens, London, W.1, quoting No. 2254 (September 4).

LECTURER IN SOCIAL SCIENCE and Supervisor of Studies for the Diploma Course in Social Science—The Registrar, University College, Singleton Park, Swansea (September 11).

CARGILL CHAIR OF NATURAL PHILOSOPHY, tenable in the subject of Theoretical Physics—The Secretary of University Court, The University, Glasgow (September 11).

ASSISTANT INSPECTORS OF MINES AND QUARRIES under the Ministry of Fuel and Power—The Secretary, Civil Service Commission, Scientific Branch, 27 Grosvenor Square, London, W.1, quoting No. 2246 (September 11).

DIRECTOR OF MUSEUMS to take charge of the Museum Section of the Art Galleries and Museums Department—The Town Clerk, City Chambers, Glasgow, C.2 (September 15).

CHAIR OF APPLIED MATHEMATICS—The Registrar, University College, Southampton (September 20).

LECTURER IN GEOLOGY, within the Department of Agricultural Chemistry, and an ASSISTANT LECTURER IN PLANT DISEASES in the Department of Agricultural Botany—The Secretary and Registrar, University College of North Wales, Bangor (September 25).

SMITHSON RESEARCH FELLOWSHIP—The Assistant Secretary, Royal Society, Burlington House, Piccadilly, London, W.1 (October 30).

TUCKER-PRICE SCIENTIFIC RESEARCH FELLOWSHIP in mathematics, science or an allied subject—The Secretary, Girton College, Cambridge (January 15).

CHEMIST IN THE DEPARTMENT OF CHEMISTRY, Tanganyika—The Director of Recruitment (Colonial Service), Colonial Office, 2 Sanctuary Buildings, Great Smith Street, London, S.W.1.

UNIVERSITY GRADUATES and QUALIFIED TEACHERS, with qualifications in mathematics, science, engineering, or in geography with mathematics up to intermediate degree standard, for Short Service Commissions in the Education Service, Royal Navy—The Director (F), Education Department, Admiralty, London, S.W.1.

LECTURER IN MATHEMATICS to B.Sc. standard, a LECTURER IN CHEMISTRY to B.Sc. standard, and a LECTURER IN PHYSICS to B.Sc. (Special) standard—The Clerk, Northern Polytechnic, Holloway, London, N.7.

TECHNICIAN FOR THE DEPARTMENT OF ZOOLOGY—The Clerk, Birkbeck College, Breams Buildings, London, E.C.4.

LABORATORY TECHNICIAN (bacteriological technique essential) IN THE PATHOLOGY DEPARTMENT—The Secretary, Welsh National School of Medicine, 10 The Parade, Cardiff.

SOIL SURVEY OFFICER—The Secretary, Rothamsted Experimental Station, Harpenden, Herts.

RESEARCH METALLURGIST, and a SENIOR ASSISTANT IN THE INFORMATION DEPARTMENT—The Secretary, British Non-Ferrous Metals Research Association, 81–91 Euston Street, London, N.W.1.

ASSISTANT TECHNICIAN for university laboratory involving botanical and chemical work—Dr. J. W. Fairbairn, School of Pharmacy, 17 Bloomsbury Square, London, W.C.1.

SCIENTIFIC ASSISTANT with a knowledge of electronics for work in X-Ray crystallography—Dr. W. A. Wooster, Cavendish Laboratory, Cambridge.

TECHNICAL OFFICER (with a degree or diploma in, and a sound practical knowledge of, horticulture)—The Curator, John Innes Horticultural Institution, 31 Mostyn Road, London, S.W.20.

VETERINARY RESEARCH OFFICERS (2) in the Sudan Veterinary Service, for supervising the preparation of various biological products and carrying out general research—The Sudan Agent in London, Wellington House, Buckingham Gate, London, S.W.1, endorsed 'Veterinary Research Officer'.

SCIENTIFIC OFFICER and EXPERIMENTAL OFFICER Grades in Ministry of Supply Research Establishments in the following fields of work: Chemistry—Inorganic, Organic, Physical, Analytical, and Chemical Engineering (Ref.F.355/48A); Biochemistry, Physiology, Pharmacology (Ref.G.184/48A); Aerodynamics—subsonic and supersonic in wind tunnels and in flight (Ref.A.160/48A); Aircraft Structural Theory (Ref.C.301/48A); Gas Turbines, jet and rocket propulsion at supersonic speeds (Ref.C.299/48A); Physics, including optics, gas kinetics and thermodynamics (Ref.A.159/48A); Radar (Ref.A.161/48A); Aircraft Instrumentation and electrical and radio accessories, etc. (Ref.C.300/48A); Metallurgy, X-Ray diffraction, electron microscopy, inter-crystalline corrosion, high temperature materials (Ref.F.356/48A); Mathematical Applications, including ballistics, statistics (Ref.A.158/48A)—The Technical and Scientific Register (K), York House, Kingsway, London, W.C.2.

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